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ABSTRACT

This report provides a summary of the activities of the Ford Program for Research in University Administration over a 5-year period. Part I provides a review of the organization of the Program. Part II is a review of the research conducted under the auspices of the Program. Part III describes the career development and dissemination activities of the Program, and Part IV outlines some suggestions for future research. Part II presents abstracts of research reports concerning outcomes of education, new concepts and analytical techniques for resource analysis, and policy analysis. Appendices include a chronological listing of report series, Ford Program Seminar Services, participants and agendas for workshops, and materials for an "Issues in College and University Management" workshop. (Author/MJM)

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FORD FOUNDATION PROGRAM FOR RESEARCH IN UNIVERSITY ADMINISTRATION

Office of the Vice President—Planning
University of California

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RESEARCH DIRECTORATE

Charles J. Hitch — President, University of California

Frederick E. Balderston — Professor of Business Administration
Chairman, Center for Research in Management Science
University of California, Berkeley
Academic Assistant to the President

OFFICE ADDRESS

2288 Fulton Street
Berkeley, California 94720
(415) 642-5490

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A PROGRAM OF RESEARCH
IN UNIVERSITY ADMINISTRATION

FINAL REPORT

October 1973

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The Ford Program for Research in University Administration was funded in May, 1968, with a grant of $500,000 for a three-year period. Additional funding in the amount of $250,000 was received August 17, 1971, for a two-year continuation of the Program. The grant terminates on October 31, 1973. This report provides a summary of the activities of the Program over this five-year period. It is organized as follows: Part I provides a review of the organization of the Program; Part II is a review of the research conducted under the auspices of the Program; Part III describes the career development and dissemination activities of the Program; and Part IV outlines some suggestions for future research.

I. Organization of the Program.

Co-principal investigators of this Program are Charles J. Hitch, President of the University of California, and Frederick E. Balderston, Professor of Business Administration, Chairman of the Center for Research in Management Science, University of California, Berkeley, and Academic Assistant to the President of the University.

An Advisory Committee of people in key academic and administrative positions reviewed the work of the Program and provided proposals for future research. This Committee has met annually in Berkeley with the Co-principal Investigators and the Research Directorate of the Program. It included:

William J. Baumol, Professor of Economics, Princeton University

Robert L. Clodius, Vice President, University of Wisconsin

Alain Enthoven, Vice President, Litton Industries, Inc.

Richard W. Judy, Professor of Political Economy, University of Toronto

Ben Lawrence, Director, National Center for Higher Education Management Systems at the Western Interstate Commission on Higher Education, and Executive Director of the National Commission on the Financing of Postsecondary Education

Jacob Marschak, Professor, Western Management Science Institute, University of California, Los Angeles

James G. March, Professor of Higher Education, Stanford University

Chester O. McCorkle, Jr., Vice President, University of California

Joseph A. Pechman, Director of Economic Studies, The Brookings Institution

Roy Radner, Professor of Economics and Statistics, University of California, Berkeley

Policy guidance and in-house research direction has been provided by a Research Directorate composed of persons with significant demonstrated ability in research and administration who have spent a year or more with the Program. This directorate has included:

Robert M. Oliver, Assistant Director, Office of Analytical Studies, University of California, with the Program 1968-1969; currently Professor, Department of Industrial Engineering and Operations Research and Chairman of the Operations Research Center, University of California, Berkeley

Stephen A. Hoenack, Assistant Director, Office of Analytical Studies, University of California, with the Program 1969-1970; currently Associate Professor, Public Administration, and Director, Management Information Division, Office of Management Planning and Information Services, University of Minnesota

George B. Weathersby, Assistant Director, Office of Analytical Studies, University of California, with the Program 1969-1972; currently a White House Fellow and Associate Director, National Commission on the Financing of Postsecondary Education

Frank A. Schmidtlein, Senior Researcher, National Institute for Education, Department of Health, Education and Welfare, with the Program 1972-1973; currently with the Center for Research and Development in Higher Education, University of California, Berkeley

Senior faculty affiliated closely with the Program have been Balderston and Roy Radner, Professor of Economics and Statistics, University of California, Berkeley. Both have served as research advisors, critics, and graduate student advisors to Program personnel.

The personnel of the Program has been composed primarily of doctoral-level graduate students at the University of California, Berkeley, who have received dissertation support and facilities for work on topics fitting into the scheme of the Program (see Part III). Additionally, post-doctoral visiting scholars have provided sources of stimulation for members of the Program. Office space, support staff and, in some cases, research grants or support were provided for the following:

Arthur M. Geoffrion, Western Management Science Institute, University of California, Los Angeles

Lewis J. Perl, Department of Industrial Relations, Cornell University

David J. Bartholomew, University of Kent, England

Ferdinand F. Leimkuhler, Department of Industrial Engineering, Purdue University

Karl A. Fox, Department of Economics, University of Iowa

David J. Breneman, Department of Economics, Amherst College

Robert Adams, Department of Economics, Cowell College, University of California, Santa Cruz

Jacob Michaelsen, Department of Economics, Cowell College, University of California, Santa Cruz

Kneale Marshall, Naval Postgraduate School, Monterey, California

Richard Grinold, School of Business Administration, University of California, Berkeley

Staff support and office space has also been provided to three visiting Ford Foundation interns: Drs. George Verberg, The Netherlands, now head of the Planning Group for Postsecondary Education, Government of the Netherlands; Sr. Ismail Orozco-Cortez, from Mexico; and Dr. Jaime C. Laya, Dean of the College of Business Administration, University of the Philippines.

Support has been provided to individuals and organizational units within the University of California system to investigate specialized topics relating

to problems of university administration. Radner has guided members of the research staff, has worked with David Wise on analyses of departmental workload statistics, and provided policy direction during Balderston's sabbatical leave to The Netherlands during the spring and summer of 1973. Dr. Eugene Hammel, Assistant Dean of the Graduate Division, University of California, Berkeley, has received funding for research and data-handling concerning graduate student flows. Professor William Bicker, Department of Political Science, University of California, Berkeley, has performed analyses of public opinion polls to assess public opinion on matters concerning higher education in California; and Arthur M. Geoffrion, Western Management Science Institute, University of California, Los Angeles, has investigated academic resource allocation models.

Some topics have been pursued jointly with analytical staffs in the Office of the Vice President - Planning in the central administration of the University of California. Among the staff professionals who have collaborated in these studies are: John E. Keller, Lucian Pugliaresi, Donovan Smith, and W. Gary Wagner. Support has also been provided for developmental work in the Office of Institutional Studies, University of California, Berkeley, of which Sidney Suslow is Director.

The Program's offices have been located at 2288 Fulton Street, Berkeley, in close proximity to the Berkeley Campus and the Office of the President of the University of California as well as the Center for Research and Development in Higher Education and the Carnegie Commission on the Future of Higher Education. Interaction with members of all of the above has greatly aided Program personnel by permitting them to become involved with on-going problems of University administration, both at the single and the

multi-campus level, as well as providing contact with other research groups concerned with similar problems of investigation and analysis.

One full-time administrative assistant and one full-time secretary have been employed throughout the Program.

II. Review of Research - Abstracts of Reports.

The guiding purpose of the Program has been to undertake research which will assist university administrators and others concerned with the management of university systems both to understand the basic functions of these complex systems and to utilize effectively the tools of modern management in the allocation of educational resources. Although there was no explicit restriction that the problems were to be exclusively identified with the University of California, it was hoped that the Program could draw upon the experiences of the faculty and administrative staff and also make use of the large files of educational, fiscal and administrative data available in the University of California. Thus, a large portion of the research which has been conducted uses University of California data or is specific to the California experience. The information and analyses can in most instances be applied also to other institutions of higher education. Our understanding of the complex organization of universities is still incomplete (and, given the dynamics of university systems, it is highly likely that it will remain so!). Nonetheless, many problem areas have proved to be susceptible to analysis, facilitating better understanding and consequently better management of large university systems.

Although universities are remarkably flexible and resilient organizations, conflicting demands put upon their resources during recent years, coupled with the current period of financial stringency, have produced serious new stresses

on them. In the past, these institutions were capable of growing in a variety of directions without having to assess mission or scope and without being so specifically accountable - financially or otherwise - to funding agencies, the tax-paying public, faculty or student bodies. That period appears to be over, and universities increasingly are being asked to justify themselves. Accountability of this sort is difficult to achieve: the problems of identifying, measuring and evaluating the components of such a complex organization are enormous. Moreover, analysis of university performance is complicated by uncertainties about how to identify and demonstrate the quantities and the merit of what is accomplished in education and research. Each year large numbers of graduates receive degrees, research is conducted in many fields and through many organizational arrangements, and public service programs are engineered, but the task of assessing the quantity and quality of each of these and justifying the nation's continued investment in them is a formidable one. This problem has been aggravated during recent years by questions of possible overproduction of new Ph.D.'s in some areas and by changed perceptions of the national priority for support of research. Some topics having to do with the benefits of higher education and markets and financing environments of universities have therefore been pursued to contribute findings that may assist in the task of accountability and that may result in improved management, greater efficiency, and more effective education.

The review of the Program's research results in the past five years is divided into three parts:

1. Outcomes of Education: Outputs; Individual and Social Benefits of Higher Education; and Supply and Demand for Educated Manpower.

2. New Concepts and Analytical Techniques for Resource Analysis:

Concepts of the Decision Process, Analytical Planning Models, and Cost and Efficiency Analyses.

3. Policy Analyses: Finance, Academic Program Effectiveness, and Educational and Institutional Changes.

Each section includes abstracts of the published reports in the area. A complete listing of reports, in chronological order, is contained in Appendix A.

1. The Outcomes of Education.

1.1. Outputs. As described earlier, concern with the outputs of institutions of higher education is an issue of interest both to university administrators and others concerned with the financing and management of universities. Defining outputs is the first task for those who would like to impose concepts of efficiency and effectiveness on educational and research processes. The National Center for Higher Education Management Systems is currently engaged in systematic work in this area, and the Carnegie Commission on the Future of Higher Education has sponsored several important studies. The following two reports by Balderston and Keller review the subject of outputs in a general manner, and together formulate a framework for further discussion and analysis.

THINKING ABOUT THE OUTPUTS OF HIGHER EDUCATION, F. E. Balderston, Paper P-5, May, 1970. Both external accountability and the necessities for coherent internal priorities have forced a rapid increase of attention to the outputs of institutions of higher education. This paper, prepared as an address to the National Research Seminar on the Outputs of Higher Education, May 3, 1970, offers a purview of some of the areas which need to be considered in concepts of output measures for education. These measures are important for the planning and management of institutions which increasingly find themselves in financial difficulty and under pressure to induce cost efficiency. The central question posed is: what difference does an exposure to higher education make in the life patterns of those who get it? Education is a transformational process, both as to the social benefit and the private benefit conferred, and it is

argued herein that its transformational character may be even greater on the social benefit side. Better measures are needed to show the nature and the extent of this transformation. Some of the indices which are available to administrators which will help determine these measures are discussed. The number of degrees produced by program and level is one measure of instructional output. Another is longitudinal data concerning the jobs and activities of former students to assess what the students have really gained in educational output. Finally, quality measures based on something more concrete than guesswork and reputation are needed to show the worth of an education with some precision and accuracy.

HIGHER EDUCATION OBJECTIVES: MEASURES OF PERFORMANCE AND EFFECTIVENESS, John E. Keller, Paper P-7, May 1970. This paper, prepared for a seminar "Management Information Systems: Their Development and Use in the Administration of Higher Education," attempts to define and clarify aspects of the problem of measuring the outputs and objectives of higher education. The author proposes some standard terminology and introduces in a relatively unstructured way some ideas which may stimulate more systematic and critical thinking on the problem of measures of outputs and objectives. The attention of the paper is confined to the question of measures for the instructional process.

Definitions of the concepts of effectiveness, outputs, benefits and efficiency and value-added are posed. Then, using these definitions, the author describes an analytic comparison system for measuring instructional efficiency. He first examines the question of total costs (including foregone income; institutional and state) and total benefits (private and public, economic and non-economic) which result from instruction in a particular field in a given institution among degree programs at various levels. He then postulates a second level of comparison concerning degree work at a given level within a given institution but covering different fields. Analysis of this sort might reveal a determinable relationship between resources invested and quality of output. The form of this relationship would be of considerable interest in that institutions would have some rough idea of the cost of changing their output quality indices.

1.2. Individual and Social Benefits of Higher Education. One approach to studies of the outputs of higher education is to assess the impact of an education upon individuals and the broad social benefits of education. This type of output study is of particular interest both in the area of assessing the efficiency and effectiveness of the educational process and in research into alternative schemes of financing education. Many economists and other social scientists have viewed the educational system as a production process.

This is the view taken by Schultz, Becker, Thurow, Taubman, Weisbrod, and others. The primary output of this process is held to be an increase in the student's stock of knowledge and skill. This output acquires value by augmenting the individual's ability to produce other goods and services. The paper (P-21) by Lewis Perl examines the usefulness of this view by estimating the relationship between specific measures of the output of the educational process at the college level and proxies for each of the dimensions of input. Many studies have concentrated specifically upon the effect of a college education upon lifetime earnings. It has generally been assumed that exposure to higher education increases an individual's earning potential, but the extent of increase and the consequent justification for alternative forms of financing education (including full-cost tuition, voucher plans, and deferred payment schemes) remain areas of debate. (See Section 3.1. for further discussion of these issues.) Several studies, including those by Weisbrod and Karpoff [1968] and Wolfe and Smith [1956] find significant correlations between such factors as high school class rank for college attenders, college class rank, and college quality, with lifetime earnings. The study by David Wise (Paper P-37) relates college and grades to the rate of salary increase and the rate of promotion. Other studies relate more specifically to the occupational mobility and flexibility of doctorate degree holders. A study by the National Research Council of a sample of doctorate recipients shows substantial amounts of occupational switching, especially among the social scientists. David Brown's study for the American Council on Education found that the degree of mobility among college professors depended to some extent on definition of subject matter specialty field. Some mobility among occupations was noted, but observed movement depended upon

how finely the subject areas in which they taught were categorized. Jeffrey Morris (Paper P-27) investigates this area as a means for identifying the degree to which the Ph.D. is transferable across occupations and the extent to which Ph.D. training is appropriate for a variety of occupational fields.

GRADUATION, GRADUATE SCHOOL ATTENDANCE, AND INVESTMENTS IN COLLEGE TRAINING, Lewis J. Perl, Paper P-21, July 1971. It has often been suggested by economists and other social scientists that the educational system may conveniently be viewed as a production process. The primary output of this process is an increase in the student's stock of knowledge and skill, and the inputs to the process including the student's time, the time of instructors, and a variety of forms of capital equipment which augment the instructional process. In order to examine the usefulness of this view, this paper attempts to estimate the relationship between specific measures of the output of the educational process at the college level and proxies for each of the dimensions of input specified above. These estimates are derived by postulating relationships between these input and output measures -- which are referred to as educational production functions -- and using multiple regression analyses to estimate the parameters of these functions. In estimating these parameters, data is used describing the inputs and outputs of the college experience for a large sample of students entering college in 1960. Such analysis is useful for the following three reasons: (1) it provides a means for evaluating the viability of viewing the educational system as a production process; (2) if consistent input-output relationships are produced, the production function can provide a useful device for evaluating the efficiency of alternative patterns of investment; and (3) the production function provides a mechanism for evaluating the importance of the advantages of high-income students and enables one to assess the usefulness of alternative means for achieving a more egalitarian distribution of educational output.

EDUCATIONAL TRAINING AND CAREERS OF PH.D. HOLDERS: AN EXPLORATORY EMPIRICAL STUDY, Jeffrey Morris, Paper P-27, January 1972. This study analyzes the occupational mobility of individuals who hold the Ph.D. It draws upon data contained in the National Register of Scientific and Technical Personnel compiled by the National Science Foundation and presents the quantitative relationships among educational background, occupational mobility and salaries. Based on these results, the author then presents and empirically tests an economic theory of Ph.D. occupational mobility. It is concluded that specialization, as defined for the NSF sample, is costly if the Ph.D. wants to move to another occupation; it is also costly if he remains employed in his field of specialization.

ACADEMIC ACHIEVEMENT AND JOB PERFORMANCE: EARNINGS AND PROMOTIONS, David A. Wise, Paper P-37, January 1973. Numerous studies of returns to investment in human capital have demonstrated that earnings are positively correlated with educational level. Persons are selected and certified in the higher educational system largely on the basis of measures of academic aptitude or performance. But the relationship between these measures and job productivity is not generally known. This paper is an examination of the relationship of measures of academic achievement and other personal characteristics to job productivity of college graduates in a particular situation. The data used pertain to persons working in a large corporation employing both technical and non-technical employees. Data on background characteristics (e.g., socioeconomic status, leadership ability, and initial work experience) salary and position in the corporation in 1968 were obtained from a survey of 1,300 persons hired by the corporation between 1946 and 1965. College quality and grades are shown to be consistently related to the rate of salary increase and the rate of promotion, although they seem not to be related to initial salary. Leadership ability and initial job experiences allowing expression of one's own ideas are also shown to be positively correlated with job performance; while a strong desire for job security is negatively associated with the rate of salary increase.

To the extent that instructional benefits generated by colleges and universities are private, some researchers argue that the costs of instruction should be borne by the students and their families. While instructional outputs are thus often seen as generating private benefits, most of the research outputs of higher education are seen as having very wide social benefit, not confined to the locality or region. Furthermore, that part of the benefits of instruction which can be construed as being social rather than private is sometimes viewed as having national or cosmopolitan rather than local or regional implications. Donald R. Winkler (Paper P-40) presents a conceptual schema for evaluating the regional benefits of higher education and reviews the implications thereof for regional finance.

THE SOCIAL BENEFITS OF HIGHER EDUCATION: IMPLICATIONS FOR REGIONAL FINANCE, Donald R. Winkler, Paper P-40, July 1973. This paper is a preliminary investigation into concepts and measures of social rather than individual benefits accruing from higher education and the implications that these have for regional finance. The nature of the

policy dilemma surrounding alternative schemes of financing higher education are discussed. A brief review of the rationale for public support of higher education; including arguments concerning redistribution of income and improved social mobility and those based on imperfections in the capital market, is offered. Regional strategies for maximizing the social benefits of higher education are discussed. A theoretical model designed to suggest pricing guidelines to a university is developed. A brief review of the activities of higher education is offered, followed by a discussion of the social benefits of higher education outputs (including the benefits resulting from instruction, socialization, certification, migration of college graduates, research and public service) and of higher education operations (including economic impacts, educational opportunity and tastes for higher education). The paper concludes by presenting a rationale for regional finance for higher education.

1.3. Supply and Demand for Educated Manpower. One of the tangible and visible outcomes of the higher educational process is educated manpower. A large part of the federal and state investment in higher education is made to guarantee continued production of trained scientific and technical manpower. Apparent surpluses of new Ph.D.'s in several fields has aroused questions about the desirability of supporting large investments for doctoral study. Financial sources of graduate student support (fellowships and traineeships) have been sharply reduced. A major policy dilemma has arisen in universities about the number and mix of doctoral-level students to produce. The policy issues are complex. Aside from the financial implications inherent in cutting back graduate enrollments, there is no easy way to predict the market demand for the Ph.D. so as to satisfy the national need for educated manpower in years hence. Universities are understandably reluctant to respond symptomatically to the current apparent surplus by immediately cutting back enrollments -- if they had done so in the 1950's, for instance, when the demand for engineers was not substantial, there would have been a critical shortage of engineers during the 1960's. Nonetheless, it would not be desirable for universities to continue to

produce Ph.D.'s in increasing numbers in fields where the prospects for appropriate future employment are uncertain. Research on the supply of and demand for educated manpower suggests that declining percentages of Ph.D.'s will find academic employment for at least another decade (see Cartter [1971] and Brode [1971]). Dael Wolfe and Charles V. Kidd ("The Future Market for Ph.D.'s," Science, 173, August 27, 1971) summarize and interpret a great deal of recent work on both supply projections and demand analysis. Balderston and Radner (Paper P-26) review the projections of academic demand for new Ph.D.'s, undertake a sensitivity analysis to show how alternative policies would affect academic demand, and draw inferences for university administrators about possible ways to adjust graduate programs to new circumstances.

Weathersby (Paper P-30) reviews more generally the structural issues in the supply of and demand for scientific manpower and analyzes the implications for national manpower policy. Philip Held (Paper P-35) looks at the question of supply of M.D.'s by examining the migration patterns of medical school graduates.

> ACADEMIC DEMAND FOR NEW PH.D.'s, 1970-90: ITS SENSITIVITY TO ALTERNATIVE POLICIES, F. E. Balderston and Roy Radner, Paper P-26, December 1971. This paper investigates the plausibility of various projections of academic demand for the doctorate over the next two decades. It examines the influence that faculty appointment in different sectors of higher education has on this demand and offers some policy implications relevant for various decision-makers involved in higher education. The report tests in some detail the soundness of recent projections of academic demand for new doctorates, discusses the way in which various factors may influence utilization by the major sectors of American higher education, and suggests some positive policy choices in the financing and staffing standards of higher education.

STRUCTURAL ISSUES IN THE SUPPLY AND DEMAND FOR SCIENTIFIC MANPOWER: IMPLICATIONS FOR NATIONAL MANPOWER POLICY, George B. Weathersby, Paper P-30, May 1972. This paper argues that, in addition to responding to surface manifestations of imbalance in scientific manpower supply and demand, we should examine and understand far better than we now do the nature and extent of the structural forces operative on the supply and demand of scientific talent. The author reviews the literature and the parameters of the current situation of an apparent surplus, and admits that there is no unanimity of opinion on what remedial policies the federal government should follow. He then argues that long-range national manpower planning must take a very broad view both of national economic and social objectives and of alternative productive technologies and that such planning must take into account the implications for both in terms of requisite manpower. Weathersby is concerned that long-term federal manpower policies are nothing more than short-term reactions dealing with symptoms rather than basic causality. He suggests that we should view the issue of manpower supply and demand from the perspective of formulation of more comprehensive, even if they be crude, national objectives, and from these deduce intermediate goals. This strategy might well lead us to significantly different conclusions about appropriate federal policies and programs.

THE MIGRATION OF THE 1955-1965 GRADUATES OF AMERICAN MEDICAL SCHOOLS, Philip J. Held, Paper P-35, January 1973. The movement and location patterns of recent medical school graduates is analyzed within the context of overall demographic, social and economic changes occurring within the U.S. Special emphasis is given to the role of medical training institutions and state financing policies of medical schools. Estimates are provided of the number of physicians locating in a state as a result of a unilateral increase in that state's public medical school graduates.

The author concludes that physician movements are similar in many ways to the overall white male migration within the U.S. The analysis of the biographic history of eleven years of medical school graduates showed that the relationship between place of practice and certain institutional factors is more complex than is commonly believed. A quantitative model is generated to test theories about factors affecting physician migration. This model is then used to estimate the effect of alternative state and national policies to effect physician migration.

2. New Concepts and Analytical Techniques for Resource Analysis.

2.1. Concepts of the Decision Process. As higher education managers are faced with increasing demands for fiscal accountability and internal efficiency and effectiveness, they have needed new concepts and analytical

techniques to improve resource analysis and decisions. Traditional resource analysis techniques have given way to systems analytic techniques. These techniques employ quantitative models of the system or area under study which assign weights to the various components and elucidate the dynamics of the system in such a way as to facilitate decision making. One report, "Complementarity, Independence and Substitution in University Resource Allocation and Operation," by F. E. Balderston (Paper P-39) explores the structural dynamics of the university to ascertain the areas of complementarity and independence among the various units. The analysis demonstrates how the dynamics of the system influence the executive decision process by creating an environment where it almost always appears rational to add programs and expand resources. Two papers (Weathersby P-6 "Decision Analysis for University and Other Public Administrators" and Schmidtlein P-42 "The Selection of Decision Process Paradigms in Higher Education") examine the dynamics of the planning process. Weathersby's is a nontechnical argument for the increased use of decision analysis in university resource allocation decisions, while Schmidtlein examines the conditions that constrain the use of both free market and planning-oriented decision processes and concludes that neither is appropriate in its pure form. Depending on the nature of the decision situation, some mix of decision techniques is required. The final paper, "PPBS in Higher Education Planning and Management," by Weathersby and Balderston (Paper P-31) analyzes the nature and the role of planning-programming-budgeting systems currently in use in higher education.

COMPLEMENTARITY, INDEPENDENCE AND SUBSTITUTION IN UNIVERSITY RESOURCE ALLOCATION AND OPERATION, F. E. Balderston, Paper P-39, August 1973. This paper looks carefully into the structure of

university operations in order to find out how to cope with an apparent contradiction between two equally respectable laws of resource commitment and budgetary adjustment - The Law of Indefinite Augmentation, and the Law of Competition at the Margin - in universities. Four domains of analysis are considered: funding; resource-inputs; processes or activities; and goals. The analysis assumes that two goals may be defined as independent of one another if an increment of change in one of them is not affected by the level of achievement of the other, complementary if the increment in attainment on the first, from a given output contribution, is positively affected by the level of attainment of the second, and (partial) substitutes if the increment of attainment of the first is negatively affected by the attainment level of the second. Given these definitions, the goals, processes, resource inputs and funds are viewed at different levels of university organization: the campus administration; the schools or colleges; the academic departments and organized research units; and the support-organizations on the campus. A brief analysis for the case of the multi-university is given.

EDUCATIONAL PLANNING AND DECISION MAKING: THE USE OF DECISION AND CONTROL ANALYSIS, George B. Weathersby, Paper P-6, May 1970. This paper was prepared as an address to the Association of Minnesota Colleges, May 1, 1970. Its purpose is to provide a concise statement of the current technology of quantitative analysis as applied to university decision making.

The author argues that quantitative decision analysis can be particularly relevant in situations involving stress, uncertainty, large amounts of resources and institutional survival. The process of decision analysis is described. It begins with the identification of a set of operationally defined variables which characterize the components of the institution relevant to the decision under study. The set of functional relationships between the controllable variables and other attributes both inside and outside the institution are investigated. This provides a mathematical description of cause and effect and input and output. The operational articulation of the characteristics of an institution which results can provide a basic talking document for the resolution of conflict and the formulation of decisions.

The current technology of decision analysis techniques and planning models is described. Several types of models are outlined: the resource prediction models, student and faculty flow models, financial management models, and management information systems. The paper concludes with a brief discussion of the motivation for decision analysis and argues strongly for its increased use in academic settings.

THE SELECTION OF DECISION PROCESS PARADIGMS IN HIGHER EDUCATION: CAN WE MAKE THE RIGHT DECISION OR MUST WE MAKE THE DECISION RIGHT? Frank A. Schmidtlein, Paper P-42, October 1973. This paper contends that there is a debate underway in higher education over the legitimacy and the effectiveness of two conceptions, or paradigms, of the processes involved in decision making. The first decision process is termed the comprehensive/prescriptive (C/P) paradigm; the second the incremental/remedial (I/R) paradigm. The C/P process is typified by modern concepts of planning, systems analysis and the use of operations research techniques. The I/R process is typified by the concepts of the "free market," incremental decision theory, and classical liberal formulations of the political process. A theory of decision process selection is proposed which suggests that neither decision process paradigm, as presented in its "ideal type" is likely to be feasible in a specific decision situation. In practice, the selection of a decision process is determined by: (1) five sets of conditions that vary among policy areas and (2) within the constraints set by these conditions, by tradeoffs made between conflicting values embodied in each decision process paradigm. An examination is made of the conditions and values associated with each paradigm and a conclusion is made that a gap exists between: (1) the assumptions held by many policy makers and (2) feasible decision processes as a result of conditions and value orientations in higher education. This gap has stimulated misdirected and ineffective strategies when attempting to deal with urgent policy concerns.

PPBS IN HIGHER EDUCATION AND MANAGEMENT: FROM PPBS TO POLICY ANALYSIS, George B. Weathersby and F. E. Balderston, Paper P-31, May 1972. Because of the interest in and increasing use of formal planning-programming-budgeting systems (PPBS), this report carefully analyzes the nature and role of PPBS and its potential impact on higher education. Part I describes the salient features of PPBS and traces the development and related analytical techniques in governmental agencies and institutions of higher education. Part II illustrates both the concepts and implementation of PPBS by a detailed explication of the University of California's experience with it. Part III suggests a form of policy analysis for educational planning which is an alternative to traditional PPBS and concludes with a case study of policy analysis applied to year-round operations and with general suggestions for managers seeking to improve their resource allocation procedures.

The benefits and complexities of PPBS may not be worth the costs in all situations, and educational institutions should carefully weigh these factors and realize that there are no easy, automatic answers to the problems of institutions of higher education.

2.2. Analytical Planning Models. A prime objective of the Program was to develop and test, in empirical applications, new techniques of analysis of university problems and new models to assist the university

decision-maker. These will be discussed both according to the substantive areas of university planning or operations to which they are directed, and the type of analytical technique employed.

Weathersby and Weinstein, in "A Structural Comparison of Analytical Models" (Paper P-12) undertook a comprehensive review of the major decision models for higher education in existence as of 1970.

> A STRUCTURAL COMPARISON OF ANALYTICAL MODELS FOR UNIVERSITY PLANNING, George B. Weathersby and Milton C. Weinstein, Paper P-12, August 1970. This paper provides a conceptual framework for the evaluation of analytical planning models designed for application in institutions of higher education. In an attempt to address the most important and difficult decisions facing managers of higher education, the majority of the analytical models that have been recently developed have focused upon the operating or capital budgets of the institution. The larger models have attempted to be comprehensive in dealing with all the expenditure components of the institution while a number of specialized models have addressed specific components of the institution in greater depth. This paper classifies the structure and scope of the models reviewed in the following categories: (1) the function or purpose of the model; (2) the theoretical foundation for the particular formulation; (3) the sources of data; (4) the subject or subjects of the model; (5) the previous and current uses of the model; and (6) the operational status of the model. After defining these terms, the paper presents a structural comparison along these major dimensions in tabular form to facilitate an evaluation of these analytical models. The major distinguishing characteristics of each model are then discussed. The paper finishes with a summary and conclusion which incorporates the author's recommendations for future research and development.

From an early point in the Program, efforts were devoted to development and empirical estimation of models of student flow from stage to stage in the educational process. Oliver (Report 68-3) and Marshall and Oliver (Report 69-1) constructed transition-probability models for this process.

> MODELS FOR PREDICTING GROSS ENROLLMENTS AT THE UNIVERSITY OF CALIFORNIA, Robert M. Oliver, Research Report No. 68-3, August 1968. The purpose of this report is to discuss and compare two mathematical models for predicting student enrollments at the University of California. One has been proposed in the scientific literature and the second has been used by

the State of California since 1963 to forecast student enrollments. The specific problems addressed in this report are the prediction of gross enrollments, i.e., freshmen, sophomores, etc., for a particular campus or the University as a whole. Although the experimental data is restricted to undergraduates, the discussion and conclusions are probably appropriate to graduate levels as well.

A CONSTANT WORK MODEL FOR STUDENT ATTENDANCE AND ENROLLMENT, Kneale T. Marshall and Robert M. Oliver, Research Report No. 69-1. The authors develop a nodel of undergraduate student attendance that relies on five parameters, one of these being a parameter of total work, w, required to complete the degree. An enrollment forecasting model consistent with these attendance patterns is developed and compared with data for the period 1961-1966, and a cohort of 2126 and 3298 freshmen entering in the fall semesters of 1955 and 1960, respectively.

Under the assumptions of the model, the probability of graduation is shown to be the w-th power of the conditional probability of successful completion of a unit of work given that a student drops out of attends and successfully completes a unit of work.

Breneman (Report 69-4), Oliver (Report 69-10) and Bartholomew (Paper P-4) explored properties of models of faculty flow through time. In a later development, Grinold worked out a dynamic-programming model of faculty flow over long time-periods in a university and computed the time transients for approach to steady-state solutions; this work was published in the journal literature.

THE STABILITY OF FACULTY INPUT COEFFICIENTS IN LINEAR WORKLOAD MODELS OF THE UNIVERSITY OF CALIFORNIA, David W. Breneman, Research Report No. 69-4. Two linear workload models of the University of California have been developed which can be used to forecast the University's demand for faculty. Both utilize a matrix of faculty input coefficients to transform a vector of student enrollment projections into a forecast of required faculty members. The purpose of the present investigation was twofold: (1) to explore the computational feasibility of a linear workload model that predicts the demand for University of California faculty by departments rather than by the currently used subject matter groups; and (2) to determine whether the faculty input coefficients are sufficently stable over time to provide meaningful forecasts. The dimensions of the departmental model are described, and a meaningful method of aggregation is proposed. Several sets of Berkeley faculty input coefficients for the years 1963-1967 are presented with an analysis of the instability evident in several of them.

AN EQUILIBRIUM MODEL OF FACULTY APPOINTMENTS, PROMOTIONS, AND QUOTA RESTRICTIONS, Robert M. Oliver, Research Report 69-10, March 1969. In this study, the author attempts to identify feasible new appointment schedules for a large tenure and nontenure faculty group in which quota restrictions have been applied to the total number of faculty appointments. It is assumed the system is in equilibrium in the sense that the flow rate of new appointments is equal to the sum of resignations, retirements and death rates.

Several models were formulated and discussed at the University of California in the fall of 1967; it soon became apparent that there was a need for a simple, informal explanation and discussion of the more complicated statistical models used to predict faculty movements, promotions, resignations and changes in rank and age distributions with the passage of time for the planning purposes of institutional administrators. This report is intended to be such a device for explaining the underlying patterns of tenure and nontenure personnel movements, and as a model for estimating the magnitude of these flows and the qualitative effect of new appointment or promotion policies.

A MATHEMATICAL ANALYSIS OF STRUCTURAL CONTROL IN A GRADED MANPOWER SYSTEM, David J. Bartholomew, Paper P-4, December 1969. This report considers a university faculty which is divided into k grades. The total size is to remain fixed but the proportions in the grades may vary. The problem is to find control strategies which will bring about changes in these proportions. This report is confined to investigating what can be achieved by controlling the numbers of new appointments made into each grade. It is assumed that movements within the system and to the outside would be governed by time homogeneous transition probabilities. A number of theorems are presented showing that not all structures can be attained and that some which are attainable cannot be maintained. Some bounds are given for the length of time needed to achieve the goal when this is possible. A number of sub-optimal strategies are proposed and their performance is studied empirically. Suggestions are made for future research.

Jonathan Halpern approached a quite different problem, the budgeting of faculty positions according to a student-faculty ratio criterion and budget restriction. He utilized branch-and-bound computational techniques for this and applied the model to quantitative estimation of faculty allocations.

BOUNDS FOR NEW FACULTY POSITIONS IN A BUDGET PLAN, Jonathan Halpern. Paper P-10, May 1970. This paper addresses the specific budgetary planning problem of new faculty positions at the University of

California. The problem is to determine the minimum number of new faculty positions that the University needs, over the next five years, in order to meet increases in student enrollment without increasing the student-faculty ratio beyond an established maximum. A mathematical model to answer this question and to find the distribution of upper and lower bounds for new positions over the five year period is formulated.

The University budgeting procedure is outlined mathematically. A set of restrictions, reflecting Regential and faculty pressure for lower student/faculty ratios and state pressures for higher ratios or more "productive" faculty are introduced. Given these restrictions, the smallest feasible increase in the number of new positions for a single campus over the planning horizon is determined, yielding the lower bound. A parallel technique discovers the upper bound. These bounds are then determined for the case of a multi-campus university. The study concludes with a discussion of extensions and other applications of the model.

Using a different type of technical characterization of the problem, that of the theory of optimal control, Rowe, Wagner and Weathersby showed control-theoretic solutions to the problem of optimal faculty staffing through time. Wagner and Weathersby followed this up, again with control-theoretic methods, in a more general optimization schema for college planning.

A CONTROL THEORY SOLUTION TO OPTIMAL FACULTY STAFFING, Steve Rowe, W. Gary Wagner and George B. Weathersby, Paper P-11, November 1970. This study investigates the resource allocation problem of faculty hiring and promotion patterns using the techniques of optimal control theory. The mathematical structure of an academic faculty is described by a linear dynamic model whose parameters were estimated from actual data by two different techniques. The principal characteristics of the faculty system considered are: (1) linear system propagation; (2) a convex preference function to rank the relative values of varying the states of the system; (3) four state variables and four control variables including the stocks and flows of (a) full professors, (b) associate professors, (c) assistant professors, and (d) instructors. The specific approach adopted for this investigation assumes that the promotion policies and attrition rates of faculty members are relatively fixed over the short run and the only variables left open to achieve a desired faculty structure are the institutional hiring policies. Under these conditions, the optimal open loop faculty hiring paths are calculated and their sensitivity investigated. The study concludes by investigating and evaluating several solution procedures.

OPTIMALITY IN COLLEGE PLANNING: A CONTROL THEORETIC APPROACH, W. Gary Wagner and George B. Weathersby, Paper P-22, December 1971. In this paper the authors argue that the decision structures of educational institutions are multi-level, multi-decision-maker hierarchies which can be described and analyzed in decision theoretic terms and that these multi-level, multi-decision-maker hierarchies can be reduced to equivalent one-level, one-decision-maker formulations, which can be solved either analytically or numerically by the techniques presented. Illustrative examples are given which identify and then solve for a set of optional resource allocation and policy decisions. The computer program used for the problem and the input data specifications are included in an Appendix.

Jewett addressed the problem of admissions planning by combining the distribution of prospective students' indicated academic ability with indicators of their ability to pay and the amounts of financial aid that a tuition-charging institution would need to consider providing to students it admitted. Jewett's estimates of the segments of admissible students in the national population, according to both academic ability-indicators and ability to pay, are of general interest. He constructed a tuition-financial-aid admissions model and applied it to the data for Ohio Wesleyan University to obtain forecasts of that institution's student population and revenue position.

COLLEGE ADMISSIONS PLANNING: USE OF A STUDENT SEGMENTATION MODEL, James E. Jewett, Paper P-23, November 1971. A major administrative and research need is the explicit integration of behavioral educational objectives, such as student body quality or student academic success, with present college costing and planning models. With this objective in mind, this study develops a freshman admissions planning model which classifies high school graduates by financial aid needed, verbal aptitude, and sex. This admissions model is used to illustrate policy alternatives with exemplary information from Ohio Wesleyan University. The market segmentation framework furnishes a unified approach to evaluate trade-offs between alternate policy strategies for tuition, financial aid, and admit/not-admit decisions. The inclusion of short-run recruitment decisions and the integration of the segmentation model with present resource planning models are natural extensions of this research. Furthermore, this segmentation model is useful in studying many national higher education problems of student access to admissions planning for individual colleges.

The Program sponsored other technical studies in significant areas of resource planning and analysis: Leimkuhler and Cooper, "Analytical Planning for University Libraries," Smith and Wagner, "SPACE: Space Planning and Cost Estimating Model for Higher Education," Sanderson, "The Expansion of University Facilities to Accommodate Increasing Enrollments," and Geoffrion, Dyer and Feinberg, "Academic Departmental Management: An Application of an Interactive Multi-Criterion Optimization Approach." The first of these was an analytical planning schema for library activities and is related to a second Leimkuhler-Cooper costing study (see Section 2.3). The second is a large-scale simulation model for space planning and control. The third utilizes brand-and-bound techniques for very long-horizon plan of the timing and location of new campuses in an expanding, multi-campus educational system. The fourth is part of a continuing program of research by Professor Geoffrion and his colleagues and their application to the reconciling of budgetary adjustments between a campus administration and individual schools or colleges.

ANALYTICAL PLANNING FOR UNIVERSITY LIBRARIES, F. F. Leimkuhler and Michael D. Cooper, Paper P-1, January 1970. A survey is made of the more important technological and managerial problems in the planning of university library services and recommendations are made for a positive program of innovation and development. Two approaches are explored in considerable detail. The first is the use of operations research models of the acquisition and storage functions. Elementary models and decision rules, based on the assumptions of exponential growth, independence of item usage, and obsolescence, are used to minimize average costs of circulation and to suggest more general models for library services.

SPACE: SPACE PLANNING AND COST ESTIMATING MODEL FOR HIGHER EDUCATION, Donovan E. Smith and W. Gary Wagner, Paper P-34, July 1972. This paper presents SPACE, a space planning and cost esimating simulation model designed to allow analysis of alternative class scheduling patterns and their consequent resource demands. Several illustrative examples of the model's use are given, with documentation of the validation procedure using data from the University of California. The examples show that changes in class scheduling patterns

have no significant effect on total operating and capital costs. A listing of the computer program and the input data specifications are included in the Appendix.

THE EXPANSION OF UNIVERSITY FACILITIES TO ACCOMMODATE INCREASING ENROLLMENTS, Robert Sanderson, Paper P-3, November 1969. A mathematical model is developed for the expansion of facilities at different campuses of the University of California for a given sequence of enrollment forecasts. Based on total projected enrollments for the University system, the model computes a minimum total cost expansion program, i.e., the stages at which to expand existing campuses or to build new ones, and the enrollments that should be allocated to those campuses. It is formulated as a network flow model in which nonzero flows on certain arcs incur fixed charges; however, for computational purposes the problem may be reduced to a linear integer program in binary variables. The model does not include such factors as graduate-undergraduate mix, departmental mix, departmental sizes, or restrictions on tenure faculty, but rather is oriented towards a method of accommodating gross enrollments. Although the assumption of continued growth upon which this model is predicated no longer hold, the techniques employed are applicable to other modelling situations.

ACADEMIC DEPARTMENTAL MANAGEMENT: AN APPLICATION OF AN INTERACTIVE MULTI-CRITERION OPTIMIZATION APPROACH, A. M. Geoffrion, J. S. Dyer and A. Feinberg, Paper P-25, October 1971. This paper presents the conceptual development and application of a new interactive approach for multi-criterion optimization to the aggregate operating problem of an academic department. This approach provides a mechanism for assisting an administrator in determining resource allocation decisions in an ever-improving sequence, and only requires local trade-off and preference information about his objectives and values.

This interactive approach is described in the context of a specific mathematical programming algorithm (the Frank-Wolfe method). The mathematical model of the operations of an academic department is then detailed. A numerical example of the use of this model coupled with the interaction procedure is provided. This example is taken from the Graduate School of Management at UCLA, where the authors are attempting to install it as a practical decision-making model. The authors conclude that the approach used here will not permit the successful treatment of many other problems in higher education not previously considered amenable to solution via mathematical programming due to multiplicity of criteria.

2.3. Cost and Efficiency Analysis. A focus on resource implications has compelled attention to cost estimates and comparisons as an incident of the study of many substantive issues pursued in the Program and discussed

elsewhere in this research review, particularly in Section 3, below, on Policy Studies. There are also important cost aspects of a number of the analytical planning models already discussed (e.g., the Smith/Wagner work on a space planning and cost estimating model, Paper P-34).

There has also been a need for careful assessment of existing general methods of analyzing the costs and efficiency aspects of institutions of higher education and applying techniques not previously used for higher education problems. These are the topics of study reviewed here.

Leimkuhler and Cooper developed a detailed description of the flow of administrative activities in a university library and estimated the size of cost components of the activity flow. Their work is in Paper P-2. Winslow performed a similarly detailed analysis of the capital plant of a University, estimated annualized costs of the capital plant (including depreciation), and showed how, under various assumptions about the assignment of space to activities, user costs of the capital plant could be allocated among activities.

> COST ACCOUNTING AND ANALYSIS FOR UNIVERSITY LIBRARIES, F. F. Leimkuhler and M. D. Cooper, Paper P-2, January 1970. This paper is a preliminary effort to develop a cost accounting model appropriate for program budgeting for library operations. The Berkeley General Library is used as a test case and, therefore, these results may not be completely general. However, some type of a cost accounting model is essential to the full implementation of program budgeting in a library system.
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> The approach to library planning studied in this report is the use of accounting models to measure library costs and implement program budgets. A cost-flow model for a university library is developed and tested with historical data from the Berkeley General Library. Various comparisons of an exploratory nature are made of the unit costs for different parts of the Berkeley system.
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> THE CAPITAL COSTS OF A UNIVERSITY, F. D. Winslow, Paper P-9, January 1971. This study focuses on data related to the capital stock of the University of California. Currently the University's capital facilities are allocated to academic departments, research institutes and campus administration on the basis of traditional

criteria such as the number of students and faculty, the magnitude of research funding and personal persuasion. One anticipates that the overall magnitude of the composition and distribution of the University's capital facilities may be very different from what it would be if capital facilities were allocated on a rational basis of cost and benefits to the university. University decision makers should be able to make the following types of choices: (1) the relative size of various educational programs by level and discipline; (2) the relative emphasis of instruction and research; and (3) the amount of support capital for administrative and service functions. This paper provides a conceptual framework and a method for analyzing these decisions. A conceptual approach to the measurement of capital costs is provided. A theory is developed and applied in a descriptive analysis of measures of capital stock and capital costs based on the Irvine campus of the University of California.

Balderston reviewed the status of cost analysis in higher education, pointing out the state of the art in derivation of cost measures and the need for careful matching of the appropriate cost concept to the kind of managerial decision on which cost information may have a bearing.

COST ANALYSIS IN HIGHER EDUCATION, F. E. Balderston, Paper P-33, July 1972. The author prepared this report as a paper for presentation to the Annual Meeting of the National Association of College and University Business Officers, held in Denver, Colorado, July 9-11, 1972. Cost analysis is of interest for: its operating and management uses within each institution; its help in providing critical inputs for planning; making major changes in capacity, program structure or institutional policies; its uses in obtaining comparisons between institutions which help in sharing insights about what targets to set for ourselves; and its valid basis in justifying to funding sources (public and private) what prices we charge for educational and institutional services. These different uses of cost analysis are discussed briefly. The author then discusses four important cost measurement issues: (1) what resources are being absorbed? (2) how does resource use vary with changes in the volume of activity? (3) is the pattern of resource use efficient? and (4) what is the trend over time? Illustrative examples of cost measures are included in the discussion, as are comments on the problems involved in attempting cost measurement. The paper concludes with a review of management strategies designed to cope with situations of financial stress.

Economists have long used the concept of the production function -- a characterization of the menu of technological alternatives for combining

inputs and transforming them into outputs -- as part of the apparatus of analysis in the theory of the firm. Daryl Carlson has available a large file of data on higher education institutions. He used linear programming methods to calculate the "efficient frontier" of resource utilization and estimated "best possible" performance for institutions with varying enrollment mixes and institutional characteristics. He then compared average production behavior with the efficient frontier.

> THE PRODUCTION AND COST BEHAVIOR OF HIGHER EDUCATION INSTITUTIONS, Daryl E. Carlson, Paper P-36, December 1972. This report consists of the doctoral dissertation (under the same title as this report) submitted to the Graduate School of Business Administration at the University of California, Berkeley. The dissertation is an empirical analysis of the "frontier" production and cost relationships between the number of students enrolled and the labor and capital inputs observed over a wide cross-section of four-year higher education institutions in the United States. In the analysis, students are differentiated as to type and as to part-time versus full-time. It is assumed that the production and cost relationships are dependent on other measurable characteristics of the institutions; therefore, several additional variables, such as institutional quality and program mix, are included in the model. Also, separate analyses are performed for each type of institution (public and private universities, public and private comprehensive colleges, and private liberal arts colleges).
>
> The empirical results generated by this study indicate that the frontier average and marginal relationships between the institutional input and enrollment variables are complex functions of input structures, enrollment mixes, and several institutional characteristics. This type of economic behavior is discouraging for national policy analysis, since it implies that no simple set of production relationships applies to all institutions. In addition, the results illustrate that the frontier production and cost relationships are not neutral, linear transformations of the average production behavior.

Colleges and universities use internal pricing ("recharge systems") for many service activities to distribute the cost of service departments over the internal users of the services. These pricing schemes are usually cost-justified. Administrative assignment and non-price rationing of scarce resources, however, are much more prevalent in guiding

the internal resource-distribution in universities, especially in direct academic operations. The Program sponsored a research workshop, in which the participants were a mixture of research analysts and senior academic administrators, to explore the potentialities and the defects of internal pricing to achieve more rational resource usage. David Breneman examined the analytical and policy issues of internal pricing in Paper P-24.

> INTERNAL PRICING WITHIN THE UNIVERSITY - A CONFERENCE REPORT, David W. Breneman (editor), Paper P-24, December 1971. This report describes the proceedings of a Conference on Internal Pricing for University Resource Allocation held in Berkeley, California, July 7-9, 1971. The conference was attended by approximately 25 economists and university administrators, who were organized into panels to discuss the theory and implementation of internal pricing. The present report contains a summary of the major issues discussed during the conference, together with four papers contributed by the participants.
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> The report is organized as follows: Section I presents an introduction to the material. Section II contains a background paper prepared by the editor and distributed to the participants in advance of the workshop; this paper provides background and focus for the topic and also describes the formal organization of the conference. Section III summarizes the major ideas, issues, agreements and disagreements that emerged in the course of the two and one-half day session. Section IV is an analytic critique of internal pricing and an agenda of issues for the future. Appendices include: a plan for a pilot project in pricing university space by Julian Decyk; notes on university resource allocation by Philip Cartwright; a structural analysis of the university resource allocation problem by Robert Crandall; and a paper on internal pricing at an institution of higher education -- implementation, planning, and information needs, by Robert Lamson.

Program analysis and budgeting have become a major issue for public higher education in many states, as state governments have moved toward adoption of program-budgeting formats and the use of program-by-program analysis. We discussed above the Ford report of Balderston and Weathersby (Paper P-31) on this subject, but it could also be considered a contribution to our work on costs and efficiency.

3. Policy Analysis.

This final section summarizes our studies in policy analysis. Some of these contribute analytical perspectives concerning the topic in question as a first step in policy formulation, others explore and compare policy alternatives, and still others provide policy recommendations.

The policy studies reported here are in three substantive areas. Section 3.1. concentrates on higher education finance; Section 3.2. on academic program effectiveness; and Section 3.3. on review and analysis of possible educational or institutional changes and improvements.

3.1. Finance. There has been growing concern about the financial stresses upon colleges and universities. The New Depression in Higher Education, Earl Cheit's well-known monograph for the Carnegie Commission on Higher Education, is an example. In a paper prepared for the American Council on Education, Balderston compared five models of fiscal stress on institutions and their implications. This appeared in the American Council on Education's proceedings volume, Universal Higher Education [1972] and is published as Paper P-29.

The California Legislature's Joint Legislative Committee on the Master Plan requested testimony on financing of higher education. Balderston reviewed financing alternatives and made policy recommendations in testimony to the Committee, reproduced as Paper P-32.

One approach to the finance of higher education is to rely much more heavily on long-term loans to students, with concurrent tuition charges to cover more of institutional costs. Balderston analyzed, in Paper P-15, the implications of different repayment periods.

VARIETIES OF FINANCIAL CRISIS, F. E. Balderston, Paper P-29, March 1972. The author examines the various forms of financial stress that academic institutions may face (he prefers the term "stress" to "crisis" because the latter implies a peak of tension that is not present in many institutions). The Earl Cheit and Alice Rivlin concepts of financial stress are reviewed. The author then offers five conceptually different models of financial stress which are briefly discussed: (1) expanded academic aspiration; (2) time passing; (3) stabilization after growth; (4) conscientious over-commitment; and (5) income tapering. The cost trends in various academic operations are described and the major educational resources used in terms of costs are reviewed. The conclusion is that the federal government is the only source that can alleviate financial problems facing higher education.

FINANCING POSTSECONDARY EDUCATION - STATEMENT TO THE JOINT COMMITTEE ON THE MASTER PLAN FOR HIGHER EDUCATION OF THE CALIFORNIA LEGISLATURE, F. E. Balderston, Paper P-32, July 1972. The author presented this paper as testimony to the Joint Committee on the Master Plan of the California legislature, Assemblyman John Vasconcelles, Chairman. The paper discusses alternative forms of financing for postsecondary education.

Most will agree that higher education is too costly to leave to the natural devices of the marketplace. The basic fiscal alternatives are: (1) to privatize the offerings of educational services and the decision to buy them; (2) to make the offerings of educational services a non-governmental function organized and offered entirely by non-profit (and possibly profit-making) corporations; and (3) to provide tax support for institutional operations and whatever degree of subsidy to the other costs of attendance may be felt necessary on public policy grounds. Each of these basic alternatives has implications for the numbers of students from each segment of society who would obtain education beyond high school, the mode of operation of educational institutions, the extent of public policy control and responsiveness to perceived public policy needs, and the incidence of cost. The author argues that the fiscal pattern that should be chosen depends on one's view of what individuals and society seek to accomplish via higher education. With these principles in mind, the author then reviews several alternative financing policies: no-tuition financing; aid to students at private institutions; student loan programs; voucher plans; and formula budgets. The author's personal recommendation based on this analysis is the following principle: that the State should meet, to the extent that the Federal government does not, the institutional costs of offering public higher education services and that California public higher education should be tuition free in all types of publicly supported institutions, for all levels of degrees, and for all ages of students.

THE REPAYMENT PERIOD FOR LOAN-FINANCED COLLEGE EDUCATION, F. E. Balderston, Paper P-15, January 1970. The author demonstrates mathematically that shifting from a grant to loan financing system for students lengthens the time before a graduate breaks even.

The implication is that all loan financing for which the repayment is concentrated in the earlier years of working life has some deterrent effect upon college attendance because the net payoff is concentrated in the later part of the working life. Since short amortization periods impose heavy burdens of cash outflows on the student and since expectations are not always correct, the author urges that loan financing of higher education be tempered by spreading risks and basing repayment on contingent income or providing for some kind of forgiveness arrangement to compensate insofar as possible for the following considerations: (1) pessimistic future income forecasts; (2) probabilistic events such as illness and disability; (3) the choice of socially valuable but low-income occupations at the time the occupational decision after college is completed; and (4) the presence of high discount rates among some students.

3.2. Academic Program Effectiveness. Two distinctively important areas of academic activity in the University of California and other major universities are medical education and the offering of Ph.D. programs. These areas of activity are also large users of academic and fiscal resources of universities. Therefore, special attention was given to issues of costs, productivity and policy in these academic areas.

David Breneman did work on Ph.D. programs resulting in three Ford Papers, P-8, P-16 and P-17. His dissertation, upon which these reports are based, won the Buchanan Prize in the Department of Economics at Berkeley.

Paul Wing undertook an analysis of medical education, including extensive cost estimation, and the results are published as Paper P-28.

AN ECONOMIC THEORY OF PH.D. PRODUCTION: THE CASE AT BERKELEY, David W. Breneman, Paper P-8, June 1970. Considerable variation in the time to degree, or "efficiency," of Ph.D. production among departments as well as variation in attrition rates is noted. A model of student behavior is proposed predicated on the following assumptions: (1) the student is viewed as an investor rather than a consumer of graduate education; (2) the investment requires the earning of the Ph.D. degree for its successful completion; (3) the investment is not properly evaluated in money terms alone; (4) the potential graduate student has limited information regarding his probability of successfully completing the degree and regarding the demand

for his services upon completion of the degree; and (5) the rational student may have sound reasons for lengthening his time to degree. Departmental differences in average time to degree may be partly explained by the above. An analysis of the behavior of the individual faculty member and the department is offered, which assumes: (1) the faculty member is assumed to be rationally attempting to maximize his own prestige; (2) departmental prestige is a function of resources and the quality of placement of its Ph.D. students within the prestige system; (3) considerations of the quality of placement forces the analysis to include the nature of demand for new Ph.D.'s in each field as a determinant of the prestige maximizing level of doctoral output; and (4) the department is shown to have control over the factors assumed to affect the rate and timing of attrition.

THE PH.D. PRODUCTION FUNCTION: THE CASE AT BERKELEY, David W. Breneman, Paper P-16, December 1970. This paper considers an alternative hypothesis to the theory of departmental behavior developed in Paper P-8 and examines the Ph.D. production function at Berkeley. A cross-section econometric analysis of 28 Berkeley departments is conducted. The inputs included in the production function are student variables -- quality and percent male; faculty variables -- quality and number; and stipend support variables -- number of T.A.'s, R.A.'s and fellowships. Estimates are given for the relative importance of each variables in explaining length of time to degree and attrition. The author argues that fellowships and research assistantships reflect the external market demand for Ph.D.'s, while teaching assistantships reflect the university's internal demand for instructional support. This interpretation leads to the question of whether a large increase in graduate student financial support, unaccompanied by growing market demands, would result in a greater output of Ph.D.'s. The production function and behavioral hypotheses are integrated by relating departmental differences in resources to an index of excess demand for Ph.D.'s by field. The author suggests that the production function hypothesis may be misleading, for increased resources unaccompanied by increased market demand may not lead to increased Ph.D. production. The paper concludes with an examination of the national production of new Ph.D.'s during the period 1947-48 to 1967-68, focusing on Berkeley's relation to total supply. It is argued that analysis of the supply side further strengthens the behavioral, demand-oriented hypothesis presented in Paper P-8.

THE PH.D. DEGREE AT BERKELEY: INTERVIEWS, PLACEMENT AND RECOMMENDATIONS, David W. Breneman, Paper P-17. This third report of a series presents the author's presentation of empirical data in support of the behavioral, demand-oriented theory of Ph.D. production. A close examination of the Ph.D. curricula of the English, Economics and Chemistry departments at Berkeley, chosen as representative of the extremes of departmental behavior, demonstrates that requirements do differ substantially and in a way designed to affect Ph.D. production. Interviews with doctoral students and faculty give a picture of

the changes in curriculum in the last twenty years and the attitudes of both groups regarding factors perceived as affecting time to degree and attrition. The concluding section contains recommendations for university policy suggested by economic analysis. Emphasis is placed on shifts away from input measures such as number of degrees produced. It is suggested that graduate enrollment quotas should be reduced for those departments showing excess attrition, allocating the positions released to departments indicating a willingness to produce and an ability to place more Ph.D.'s. It is recommended that applicants to doctoral programs be provided with detailed information on the probability of earning the Ph.D., mean time to degree, student support, and recent placement experience of the department. The author further recommends that enrollment quotas be consistent with each department's desired output and that departments be encouraged to discover unfilled needs for training and create new programs to fill those needs.

PLANNING AND DECISION MAKING FOR MEDICAL EDUCATION: AN ANALYSIS OF COSTS AND BENEFITS, Paul Wing, Paper P-28, January 1972. This paper, which is the author's doctoral dissertation for the Industrial Engineering and Operations Research Department at the University of California at Berkeley is an attempt to clarify the role of medical education in the larger health care system, to estimate the resources required to carry on medical education programs, to estimate the benefits that accrue from medical education, and to answer a few fundamental policy questions. Cost estimates are developed on a program by program basis, using empirical economic analysis as well as the results of previous studies. Benefits are also discussed on a program by program basis, with quantitative estimates where appropriate and feasible. The analysis raises some serious questions about the advisability of continued expansion of medical education in the U.S. Suggestions for future research are discussed.

By couching the discussion primarily in terms of the factual bases for decisions regarding medical education, this paper provides a rather different perspective on the subject than is usually seen. This reveals inadequacies in many studies of both costs and benefits of medical education, but it also suggests in a constructive sense both improvements that can be made in these analyses and priorities for future work.

Finally, Luis Llubia developed concepts for a program analysis of the Schools of Business Administration at the University of California, Berkeley, in Paper P-18.

AN ANALYSIS OF THE SCHOOLS OF BUSINESS ADMINISTRATION AT THE UNIVERSITY OF CALIFORNIA, BERKELEY, Luis L. Llubia, Paper P-18, December 1970. This study is a preliminary analysis of the undergraduate and graduate Schools of Business Administration on the Berkeley campus of the University of California. The purpose of this investigation is to address some of the major policy questions facing these schools

and to provide a basic framework for comparable analyses in other institutions.

The paper begins by presenting the formal organization of the Schools and identifying who makes what decisions. Then it proceeds to discuss some concepts of decision theory which regard an organization from the points of view of the decision makers. It then examines several decision problems in an attempt to identify the decision maker's information needs. Any research activities as well as faculty promotion processes are explicitly excluded. The last chapter attempts to look at the Schools from the point of view of the Dean. Thus, some of the interdependencies that exist between the degree programs and the consequences of some policy questions of current interest are examined.

3.3. Educational and Institutional Changes. Part of the task of the Program was to show how illustrative policy analyses could be performed in difficult areas of assessment and decision. We report here five such studies, each of which is also concerned with a significant area of change in the character of academic programs or policies: Pugliaresi's study of a new type of degree in P-13; Kreplin's comprehensive review of the usage of credit by examination in P-20; the work of Adams and Michaelsen on evaluation of the structurally different collegial arrangement at the University of California Santa Cruz in P-14; MacLachlan's cost benefit study of a possible scheme of dissemination of research publications in P-38; and the report of Kreplin and Bolce on a review and analysis of interinstitutional cooperation in higher education.

INQUIRIES INTO A NEW DEGREE: THE CANDIDATE IN PHILOSOPHY, Lucian S. Pugliaresi, Paper P-13, November 1970. Pugliaresi discusses the pros and cons of formally recognizing the achievement of candidacy status by awarding a Candidate in Philosophy degree. The purpose of the study is to explore both the institutional economic impact of the new degree and to determine whether the University of California at Berkeley created a net benefit by what appeared to be a costless operation, i.e., certifying candidacy status. The author concludes that although marginal costs of the degrees were zero in terms of expenditures, there were costs to the public and students that outweigh benefits the degree might bring. The author also concludes that the degree does not seem to fulfill requirements for employment in the community college faculty market.

CREDIT BY EXAMINATION: A REVIEW AND ANALYSIS OF THE LITERATURE, Hannah S. Kreplin, Paper P-20, July 1971. This paper examines programs of course credit by examination in American higher education. After a brief sketch of the credit-hour system, various programs in actual operation are described. The ensuing analysis focuses on the following issues: appropriateness of various subject matters to programs of credit by examination; attitudes toward credit by examination; results for participating students of credit by examination programs; financial costs and benefits of credit by examination; patterns of examination design and administration. The analysis suggests that although many institutions sponsor credit by examination programs, the policy problems surrounding them as alternative to course work have prevented their widespread use.

ASSESSING THE BENEFITS OF COLLEGIATE STRUCTURE: THE CASE AT SANTA CRUZ, Robert F. Adams and Jacob B. Michaelsen, Paper P-14, February 1971. This report presents the preliminary results of an effort to identify and measure the benefits stemming from one kind of departure from the dominant departmental structure of the modern university. Because money costs of programs in higher education are easier to identify than benefits, a successful effort of this kind is a prerequisite to determining whether such a departure is worthwhile.

Part I is an economist's view of undergraduate education. Several of the possible outputs of higher education are described for the purpose of measuring the extent to which the structure of the Santa Cruz campus facilitates their production: private producer capital, private consumer capital, discovery of talent, production of social capital in citizenship, and the development of "current consumption benefits" or quality of life in the academic communities. Part II then reviews some major criticisms of structuralist reforms. Part III looks at the organization and substance of undergraduate educational programs to see whether, in a collegiate university, significant educational programs can be mounted which are unlikely to arise elsewhere. Part IV describes the collegiate structure of the Santa Cruz campus, beginning with a description of how decisions are made and closing with a set of hypotheses about the characteristics of Santa Cruz graduates. This is followed by an evaluation of the collegiate structure and with a specification and measurement of the benefits resulting from it. The paper concludes with some recommendations for supporting collegiate programs.

A PLAN FOR A PUBLICATION NETWORK FOR RAPID DISSEMINATION OF TECHNICAL INFORMATION, James MacLachlan, Paper P-38, June 1973. There is a need for networks that will move readily perishable technical information to its audience before its utility is lost. This paper outlines a plan for a publication network for rapid dissemination of such information. This plan would establish a network of depositories at universities and research organizations where working papers, technical reports and other materials would be available quickly to the local user who would pay a small price per page. The author or

originating sponsor would pay for the initial publication run at the local depository's standard price per page for the number of copies necessary, plus the mailing costs to his mailing list for and to other depositories in the network. Various forms of reproduction, including offset printing, xerox and micro-fiche, would be compatible with the system, as would computerized literature search data bases which could be used to develop a bibliography of appropriate working papers. Many different organizational configurations could be considered when designing a network. An example of one such configuration which considers level of royalties, copyright, quality control, advertising and promotion is given. A proposal is made for a prototype network to disseminate research reports and working papers from graduate schools of business administration, and a financial analysis is given.

INTERINSTITUTIONAL COOPERATION IN HIGHER EDUCATION: AN ANALYSIS AND CRITIQUE, Hannah S. Kreplin and Jane W. Bolce, Paper P-41, October 1973. Relying in part on ideas generated during a Ford Program-sponsored workshop on interinstitutional cooperation, November 2-3, 1972, this report attempts to draw together and critically analyze available information in this currently crucial area of higher education. Following the presentation of analytical perspectives and questions, definitions, varieties of structural arrangements, incentives and obstacles to cooperation, planning and management strategies, and the voluntary-involuntary governance issue are discussed in turn. A brief summary and conclusion completes the paper.

III. Career Development and Dissemination.

A. Career Development. A more than incidental consequence of the Program has been to interest exceptionally able young people in university planning and administration and further their education and career development. Skilled analysts capable of carrying out independent investigation pertaining to problems of university administration and policy analysis are in short supply. Much of the research conducted by the Program has been carried out by graduate students at the University of California, Berkeley, who were employed part-time in research capacities. Many have since gone into careers relating to university and higher education planning and analysis or have accepted academic appointments. The following is a partial list of former Program personnel and their

present employment:

David W. Breneman, Staff Director of the National Board on Graduate Education, Washington, D.C.; on leave from the Department of Economics, Amherst College

Daryl Carlson, Assistant Professor, Department of Agricultural Economics, University of California, Davis

Michael Cooper, Assistant Professor, School of Librarianship, University of California, Berkeley

Jonathan Halpern, analyst with TECHNION, the Haifa Institute of Technology, Haifa, Israel

Philip Held, analyst with MATHEMATICA, Princeton, New Jersey

Stephen Hoenack, Associate Professor, Public Administration, and Director, Management Information Division, Office of Management Planning and Information Services, University of Minnesota

David Hopkins, Staff Associate, Academic Planning, Stanford University

Jeffrey Morris, Assistant Professor, Department of Economics, University of Washington, Seattle

Hannah Kreplin, Specialist, Center for Research and Development in Higher Education, University of California, Berkeley

Lucian Pugliaresi, analyst with the Office of Analytical Studies, University of California, Office of the President

Ralph Purves, Assistant Research Economist with the Carnegie Commission on the Future of Higher Education and the Center for Research and Development in Higher Education, Berkeley

Robert Sanderson, with Fair-Isaac & Co., Management Consultants, San Rafael, California

Frank Schmidtlein, Specialist with the Center for Research and Development in Higher Education, University of California, Berkeley

Gary Wagner, analyst with the Office of Analytical Studies, University of California, Berkeley

Thomas Walsh, Assistant Professor, Department of Public Affairs, State University of New York, Albany

George B. Weathersby, Associate Director, National Commission on the Financing of Postsecondary Education

Paul Wing, Project Director, National Center for Higher Education Management Systems, Western Interstate Commission on Higher Education, Boulder, Colorado

Donald Winkler, Assistant Professor, Department of Economics, University of California, Santa Barbara

David Wise, Assistant Professor, Kennedy School of Government, Harvard University

B. Seminars, Workshops and Conferences. Throughout the term of the Program, an informal seminar series was held during the academic year and the summer months to permit Program personnel both to air their research findings to a wider audience and to hear about the work of others on topics of interest. A list of seminar speakers and topics is provided in Appendix B.

The Program also sponsored five formal conferences or workshops on topics of major interest to university administrators:

Workshop on Library Planning Models, Saturday, February 28, 1970; a discussion on the feasibility of implementing techniques similar to that proposed in Papers P-1 and P-2

Conference on Analytical Planning Models (co-sponsored by the Western Interstate Commission on Higher Education), March 11-12, 1971; a review of the technology of planning, discussions of feasibility of implementation and use of models in policy analysis

Workshop on Internal Pricing, July 7-9, 1971; a summary of this workshop is detailed in Paper P-24

Workshop on Interinstitutional Cooperation in Higher Education, November 2-3, 1972; proceedings summarized in Paper P-41

Workshop for purposes of discussing concerns and sharing information about the National Center for Higher Education Management Systems, January 10, 1973 (co-sponsored by the Office of the Vice President-Planning, University of California, Berkeley).

Lists of attenders and agendas for these workshops are in Appendix C.

The Program also sponsored a week-long Seminar on Issues in College and University Management, July 18-24, 1971. Over ninety participants and twenty-five speakers participated in this seminar. This covered a wider range of topics than the workshops sponsored by the Program. The

Seminar dealt with a number of key issues intended to convey the generally applicable research findings of the Program and other efforts to a broad spectrum of high-level academic and public administrators involved in higher education. Distinguished guest speakers, panel discussions, participant-led presentations and a specially designed interactive computer-based decision exercise addressed various key topics in higher education management which included: the financial crisis, academic planning, costing issues, faculty workload and compensation, and governance problems. Most participants paid a fee to attend the seminar and paid costs of room and board for the one-week interval, but provision was made for a number of fee waivers and for some full scholarships to the seminar in order to assure broad access to the seminar. Appendix D contains descriptive materials on this seminar.

C. Dissemination. A substantial portion of the Program's budget has been used to publish and circulate research reports to institutions and interested individuals. The mailing list of the Program has grown over the years and currently contains approximately seven hundred names. Additional requests for reprints, averaging around 175 reports per month, have come from a variety of sectors. These reports have been mailed free of charge. This continuing demand is an indication that the Program's research reports are found to be helpful and pertinent to current problems of administration and analysis. In order to insure continuing availability of the report series upon the expiration of the grant, a recharge system has been established with the Center for Research in Management Science at the University of California, Berkeley, which will make reports available to interested individuals at cost. This system will enable additional production runs of high-demand documents to be made when the need arises.

Information on the cost of reports and the method for obtaining them is in Appendix A.

Authors of Ford Program reports have been encouraged to publish their findings in the journal literature and to appear on programs at national meetings of scholarly organizations and professional groups. Work done in the Program has attained very wide visibility through these individual efforts, but we will not attempt in this report to give details.

IV. Needs for Further Research.

The problems of administration and management of major universities have received increasingly systematic analytical attention in recent years, and the review of the Program's contributions in the preceeding section shows, we believe, a considerable span of contributions both to technique and to substantive issues.

A period of sustained difficulty lies ahead for major universities. Graduate education is undergoing some reorientation to moderate the numbers of Ph.D.'s trained for university academic appointment and to respond to social demands for trained manpower in other areas, while adjustments must be made to the tapering off of undergraduate as well as graduate enrollment growth.

Major universities, public and private, face increasingly intricate problems of combining various financing sources for their undergraduate and graduate educational programs and their related commitments in scholarly research. Federal and foundation research funding has become more problematical with changes of national priorities and attention-focus, and graduate fellowship funds have already been sharply curtailed in many fields. At the same time, costs of operation continue to be pressed upward by inflationary forces that bear disproportionately on universities

as compared with the movements of the general price level.

How the major universities are to adjust to a nearly steady-state, no-growth environment without losing their viability is not clear. Institutional decision-makers and planners face complex issues of priority and efficiency and are searching for appropriate mechanisms of institutional adjustment. At the same time, major universities are increasingly affected by the growing superstructures of planning, control and accountability at Federal and state levels.

There remain significant needs, we believe, both for technical development and for substantive analysis to assist major universities toward better courses of action through this difficult period. Briefly, we note these areas of future research priority:

1. Analysis of internal patterns of interdependence of academic and related activities of universities, to discover possible ways to rearrange the manner in which resources are combined to produce the several kinds of contributions to society that are expected of the major universities;

2. Elaboration of ways whereby quality as well as quantity of university performance can be characterized;

3. Study of critical factors in the market and funding environment of major universities; and

4. Examination and possible design of mechanisms for adjusting planning goals and priorities to new circumstances.

While some efforts are being devoted to these issues, the case of the major universities needs specialized and sophisticated attention.

APPENDIX A

PUBLISHED REPORTS

68-3: Oliver, R. M., *Models for Predicting Gross Enrollments at the University of California.*

69-1: Marshall, K. and R. M. Oliver, *A Constant Work Model for Student Attendance and Enrollment.*

69-4: Breneman, D. W., *The Stability of Faculty Input Coefficients in Linear Workload Models of the University of California.*

69-10: Oliver, R. M., *An Equilibrium Model of Faculty Appointments, Promotions, and Quota Restrictions.*

P-1 : Leimkuhler, F. and M. Cooper, *Analytical Planning for University Libraries.*

P-2 : Leimkuhler, F. and M. Cooper, *Cost Accounting and Analysis for University Libraries.*

P-3 : Sanderson, R. D., *The Expansion of University Facilities to Accommodate Increasing Enrollments.*

P-4 : Bartholomew, D. J., *A Mathematical Analysis of Structural Control in a Graded Manpower System.*

P-5 : Balderston, F. E., *Thinking About the Outputs of Higher Education.*

P-6 : Weathersby, G. B., *Educational Planning and Decision Making: The Use of Decision and Control Analysis.*

P-7 : Keller, J. E., *Higher Education Objectives: Measures of Performance and Effectiveness.*

P-8 : Breneman, D. W., *An Economic Theory of Ph.D. Production.*

P-9 : Winslow, F. D., *The Capital Costs of a University.*

P-10: Halpern, J., *Bounds for New Faculty Positions in a Budget Plan.*

P-11: Rowe, S., W. G. Wagner and G. B. Weathersby, *A Control Theory Solution to Optimal Faculty Staffing.*

P-12: Weathersby, G. B. and M. C. Weinstein, *A Structural Comparison of Analytical Models.*

P-13: Pugliaresi, L. S., *Inquiries into a New Degree: The Candidate in Philosophy.*

P-14: Adams, R. F. and J. B. Michaelsen, *Assessing the Benefits of Collegiate Structure: The Case at Santa Cruz.*

P-15: Balderston, F. E., *The Repayment Period for Loan-Financed College Education.*

PUBLISHED REPORTS (continued)

P-16: Breneman, D. W., *The Ph.D. Production Function: The Case at Berkeley.*

P-17: Breneman, D. W., *The Ph.D. Degree at Berkeley: Interviews, Placement, and Recommendations.*

P-18: Llubia, L., *An Analysis of the Schools of Business Administration at the University of California, Berkeley.*

P-20: Kreplin, H. S., *Credit by Examination: A Review and Analysis of the Literature.*

P-21: Perl, L. J., *Graduation, Graduate School Attendance, and Investments in College Training.*

P-22: Wagner, W. G. and G. B. Weathersby, *Optimality in College Planning: A Control Theoretic Approach.*

P-23: Jewett, J. E., *College Admissions Planning: Use of a Student Segmentation Model.*

P-24: Breneman, D. W., (editor), *Internal Pricing within the University--A Conference Report.*

P-25: Geoffrion, A. M., J. S. Dyer and A. Feinberg, *Academic Departmental Management: An Application of an Interactive Multi-criterion Optimization Approach.*

P-26: Balderston, F. E. and R. Radner, *Academic Demand for New Ph.D.'s, 1970-90: Its Sensitivity to Alternative Policies.*

P-27: Morris, J., *Educational Training and Careers of Ph.D. Holders: An Exploratory Empirical Study.*

P-28: Wing, P., *Planning and Decision Making for Medical Education: An Analysis of Costs and Benefits.*

P-29: Balderston, F. E., *Varieties of Financial Crisis.*

P-30: Weathersby, G. B., *Structural Issues in the Supply and Demand for Scientific Manpower: Implications for National Manpower Policy.*

P-31: Weathersby, G. B. and F. E. Balderston, *PPBS in Higher Education Planning and Management.*

P-32: Balderston, F. E., *Financing Postsecondary Education--Statement to the Joint Committee on the Master Plan for Higher Education of the California Legislature, April 12, 1972.*

P-33: Balderston, F. E., *Cost Analysis in Higher Education.*

PUBLISHED REPORTS (continued)

P-34: Smith, D. E. and W. G. Wagner, *SPACE: Space Planning and Cost Estimating Model for Higher Education.*

P-35: Held, P., *The Migration of the 1955-1965 Graduates of American Medical Schools.*

P-36: Carlson, D. E., *The Production and Cost Behavior of Higher Education Institutions.*

P-37: Wise, D. A., *Academic Achievement and Job Performance: Earnings and Promotions.*

P-38: MacLachlan, J., *A Plan for a Publication Network for Rapid Dissemination of Technical Information.*

P-39: Balderston, F. E., *Complementarity, Independence and Substitution in University Resource Allocation and Operation.*

P-40: Winkler, D. R., *The Social Benefits of Higher Education: Implications for Regional Finance.*

P-41: Kreplin, H. S., and J. W. Bolce, *Interinstitutional Cooperation in Higher Education: An Analysis and Critique.*

P-42: Schmidtlein, F. A., *The Selection of Decision Process Paradigms in Higher Education: Can We Make the Right Decision or Must We Make the Decision Right?*

These reports are available from the Center for Research in Management Science, University of California, 26 Barrows Hall, Berkeley, California 94720, for $1.95 each ($1.45 each for additional copies of the same report). Please add California sales tax if applicable. Checks should be payable to Regents of the University of California.

APPENDIX B

FORD PROGRAM SEMINAR SERIES -- SPEAKERS AND TOPICS

(in chronological order)

Robert M. Oliver, Assistant Director, Office of Analytical Studies, University of California, Berkeley, "Some Constant Work Models of Student Attendance and Enrollment"

Mike Echols, Graduate Student, University of California, Berkeley, "40-60 Ratio and the Impact of Diversion on Enrollment Projects"

Richard Judy, Professor of Political Economy, University of Toronto, "A Review ot the University of Toronto CAMPUS Planning Model"

Robert M. Oliver, "Faculty Promotions, Retirements and Tenure Restrictions"

Robert Sanderson, Graduate Student, Operations Research, University of California, Berkeley, "Expansion of University Facilities to Accommodate Increasing Enrollments"

Lewis Perl, Administrative Analyst, Office of Analytical Studies, University of California, "Predicting College Performance"

Leonard Miller, Assistant Professor of Social Welfare, University of California, Berkeley, "Resource Requirements for Education and Equality of Educational Opportunity"

Bart McGuire, Professor, Graduate School of Public Policy, University of California, Berkeley, "Remarks on Academic Planning for a Single Campus"

Roy Radner, Professor of Economics and Statistics, University of California, Berkeley, "An Input-Output Model for the University of California"

Joseph Gani, Visiting Professor, Department of Probability and Statistics, The University, Sheffield, England, "Mathematical Models for Predicting University Enrollments"

David Bartholomew, Visiting Professor, The University, Canterbury, Kent, England, "Observations on Models of Faculty Flows"

Arthur Geoffrion, Western Management Science Institute, University of California, Los Angeles, "Resource Allocation at UCLA"

Robert F. Adams and Jacob Michaelsen, Department of Economics, University of California, Santa Cruz, "Assessing the Benefits of Collegiate Structure: The Case at Santa Cruz"

Alex Mood, Public Policy Research Organization, University of California, Irvine, "New Models of Higher Education"

William Bicker, Assistant Professor, Political Science, University of California, Berkeley, "Bears, Governors and Goats"

Paul Wing, Analyst, Office of Health Planning, Vice President--Planning and Analysis, University of California, "Cost-Benefit Analysis of Medical School Programs"

Tom Walsh, Graduate Student, Economics, University of California, Berkeley, "Overhead Costing"

F. E. Balderston, Vice President--Planning and Analysis, University of California, "Institutional Perspectives"

Robert Ramey, Graduate Student, Business Administration, University of California, Berkeley, "An Approach to the Selection of Investment Strategy in a University"

Clinton Powell, Office of Health Planning, University of California, "University Ten-Year Health Plan"

Fred Winslow, Graduate Student, Business Administration, "Internal Pricing of University Capitol Stock"

Robert Adams, Office of Planning and Analyses, University of California, Santa Cruz, "Planning at UC Santa Cruz"

David Breneman, Graduate Student, Economics, University of California, Berkeley, "An Analysis of the Production of Ph.D.'s at Berkeley"

William Bicker, "An Analysis of Public Opinion Polls"

Eugene Lee, Director, Institute of Governmental Studies, University of California, Berkeley, "Governance of a Multi-Campus University"

Sidney Suslow, Director, Office of Institutional Research, University of California, Berkeley, "Enrollment Quotas and Planning"

Eugene Hammel, Assistant Dean, Graduate Division, University of California, Berkeley, "Migration of Ph.D.'s"

John Coons, Professor of Law, University of California, Berkeley, "Wealth Equilization Plans for Financing Public Education"

Ron Loshin, Analyst, Office of Analytical Studies, University of California, "Tuition Plans"

Ernest Palola, Center for Research and Development in Higher Education, University of California, Berkeley, "Statewide Planning for the 70's"

Jonathan Halpern, Graduate Student, Industrial Engineering and Operations Research, University of California, Berkeley, "Ratios of Performance Criterion in Budgetary Planning"

Arthur Geoffrion, "Analysis of Models and Research Planning"

Lou Pugliaresi, Analyst, Office of Analytical Studies, University of California, "An Analysis of the Candidate in Philosophy Degree"

F. E. Balderston, Chairman, Center for Research in Management Science, and Don Winkler, Graduate Student of Economics, University of California, Berkeley, "Regional Impact and Justification for Regional Finance of Universities"

Thomas McCullough, Graduate Student, Business Administration, University of California, Berkeley, "A Campus Planning Model"

Joseph Pechman, Director of Economic Studies, Brookings Institution, "The Financing of Higher Education"

Paul Taubman, Professor of Education, University of Pennsylvania, "Mental Ability and Higher Educational Attainment in the 20th Century"

F. E. Balderston, "Cost Analysis in Higher Education"

George Weathersby, Associate Director, Office of Analytical Studies, University of California, "Reflections on Educational Attainment in Nigeria"

David Wise, Graduate Student, Economics, University of California, Berkeley, "Selection and Certification in Higher Education"

Alan Cartter, Carnegie Commission on Higher Education, "Graduate Education and the Academic Labor Market"

Daryl Carlson, Graduate Student, Economics, "Production Behavior of Institutions of Higher Education"

Charles Benson, Professor of Education, University of California, Berkeley, "Reform of School Finance"

J. Victor Baldridge, School of Education, Stanford University, "Relationships between Environmental Pressures and Professional Autonomy in Higher Education"

Tom Dalglish, Graduate Student, School of Education, University of California, Berkeley, "Legal Issues in University Governance: Constitutional Autonomy - Administrative Procedures - Legislation"

Frank A. Schmidtlein, Graduate Student, School of Education, University of California, Berkeley, "Planning Paradigms"

Philip Held, Graduate Student, Economics, University of California, Berkeley, "Physician Migration"

Donald Winkler, "The Regional Impact of Institutions of Higher Education"

Hannah Kreplin, Graduate Student, Sociology, University of California, Berkeley, "The Evaluation of Individual Abilities in Higher Education"

George Weathersby, "Supply and Demand for Scientific and Technical Manpower"

Gary Wagner, Analyst, Office of Analytical Studies, University of California, "Optimal Control Model of Private Colleges"

David Breneman, Assistant Professor of Economics, Amherst College, "Internal Pricing for University Resource Allocation"

Donald Winkler, "The Rationale for Regional Finance of Higher Education"

Hannah Kreplin and Jane Bolce, "Interinstitutional Cooperation in Higher Education"

Frank Schmidtlein, "Decision Processes and their Structural Implications"

James MacLachlan, Graduate Student, Business Administration, University of California, Berkeley, "A Proposed Network for Distribution of Working Papers and Technical Reports"

Tom Dalglish, "Law and University Research"

David Wise, "Instructional Activity, Efficiency and Workload"

F. E. Balderston, "Planning of Postsecondary Education in the Netherlands"

APPENDIX C

WORKSHOP ON LIBRARY PLANNING MODELS

February 28, 1970

Dr. Ferdinand Leimkuhler
Purdue University

Dean R. C. Swank
School of Librarianship
UC Berkeley

Dr. James E. Skipper
University Librarian
UC Berkeley

Mr. Michael Cooper
School of Librarianship
UC Berkeley

Professor E. A. Wight
School of Librarianship
UC Berkeley

Professor M. E. Maron
School of Librarianship
UC Berkeley

Professor P. G. Wilson
School of Librarianship
UC Berkeley

Mr. Don Davidson
Secretary, Library Council
UC Santa Barbara

Dr. John E. Smith
University Librarian
UC Irvine

Dr. Melvin J. Voigt
University Librarian
UC San Diego

Dr. Donald T. Clark
University Librarian
UC Santa Cruz

Mr. Charles Courey
Office of the Vice President —
Planning & Analysis
UC Statewide Offices

Mr. Ralph Wilcoxin
School of Architecture
UC Berkeley

Ms. Page Ackerman
Assistant University Librarian
UC Los Angeles

Mr. Lee J. Mosley
Coordinating Librarian
UC Medical Center

Mr. R. P. Lang
Assistant University Librarian
UC Riverside

Mr. Don Bosseau
Assistant University Librarian
UC San Diego

LIBRARY PLANNING MODELS

WORKSHOP AGENDA

9:45 - 10:00 - Coffee

10:00 - 10:15 - Welcome and Introduction - Vice President Balderston

10:15 - 11:00 - Presentation by Professor Leimkuhler

11:00 - 12:00 - Discussion

12:00 - 1:30 - Luncheon - Faculty Club

1:30 - 3:00 - Discussion

Major Questions - The relevance of analytical models to University of California Library Planning

- What models are relevant

- How planning can be facilitated

ANALYTICAL PLANNING MODELS CONFERENCE

March 11-12, 1971

Conference Participants

Dr. Gary Andrew
University of Minnesota

Dr. Frederick Balderston
Chairman, Center for Research in
Management Science
UC Berkeley

Dr. Elwin Cammeck
Director-Planning and Analysis
University of Wisconsin

Dr. James S. Dyer
Graduate School of Management
UC Los Angeles

Mr. James Farmer
Systems Research, Inc,
Los Angeles, California

Mr. Karl Fox
Department of Economics
University of Iowa

Dr. Arthur Geoffrion
Western Management Science Institute
UC Los Angeles

Dr. Warren Goodell
Vice President-Administration
Columbia University

Dr. Warren Gulko
WICHE-PMS
Boulder, Colorado

Dr. A. G. Holzman
Department of Industrial Engineering
University of Pittsburgh

Dr. Ben Lawrence
WICHE-PMS
Boulder, Colorado

Dr. Ferdinand Leimkuhler
Department of Industrial Engineering
Purdue University

Dr. William Lewis
Associate Provost
Princeton University

Dr. C. Bartlett McGuire
Graduate School of Public Policy
UC Berkeley

Dr. Arnold Reisman
Operations Research
Case Western Reserve University

Mr. Michael Roberts
Analytical Studies
Stanford University

Dr. Timothy Ruefli
School of Business
University of Texas

Mr. Donovan Smith
Specialist in Physical Planning
UC Statewide Offices

Dr. Lawrence Southwick
School of Management
State University of New York-Buffalo

Mr. Paul Teplitz
Office of Analytical Studies
Massachusetts Institute of Technology

Analytical Planning Models Conference
Conference Participants - continued

Dr. George Tracz
Ontario Institute for Studies
in Higher Education
Toronto, Ontario

Dr. Ismail Turksen
Department of Industrial Engineering
University of Toronto

Mr. George Verberg
Visiting Ford Scholar
The Netherlands

Dr. Robert Wallhaus
WICHE-PMS
Boulder, Colorado

Dr. George Weathersby
Office of Analytical Studies
UC Berkeley

Mr. John Wynne
Vice President-Administration and Personnel
Massachusetts Institute of Technology

Dr. Willard Zangwill
Sullivan Educational Systems
Palo Alto, California

ANALYTICAL PLANNING MODELS CONFERENCE

AGENDA

Thursday, March 11, 1971

9:00 a.m.	Introductions
9:15	Discussion:
	1. Current status of analytical modeling efforts
	- Relevant, decision oriented research - Characteristics of analytical models - Assets/Deficiencies - Currently unsolved conceptual or technical problems
12:00	Luncheon
1:30 p.m.	Discussion:
	2. Problems of implementation
	Organizational: - Organizational structure - Bureaucratic location of analysis - Process of program review - Education of executives - Reluctance to use analysis explicitly - Relationship to fundors

Friday, March 12, 1971

9:00 a.m.	Discussion:
	1. Continuing discussion of problems of implementation
	Technical: - Data and Data Systems - Analytical Techniques - Computer Limitations - Technical Personnel Limitations
12:00	Luncheon
1:30	Future Research and Developments

WORKSHOP ON INTERNAL PRICING MECHANISMS

FOR UNIVERSITY RESOURCE ALLOCATION

July 7-9, 1971

Workshop Participants

Dr. Robert Adams
Department of Economics
UC Santa Cruz

Dr. Frederick E. Balderston
Chairman, Center for Research in
Management Science
UC Berkeley

Dr. David W. Breneman
Department of Economics
Amherst College

Dr. David G. Brown
Executive Vice President-
Academic Affairs
Miami University

Dr. Philip Cartwright
Executive Vice President
University of Washington

Dr. Salvatore Corrallo
Office of Program Planning and
Evaluation
United States Office of Education

Dr. Robert Crandall
School of Business
Queens University
Kingston, Ontario

Mr. Donald Davidson
University Librarian
UC Santa Barbara

Dr. James Doi
Dean, College of Education
University of Rochester

Mr. Alan Grundmann
Office of Physical Planning
Stanford University

Mr. Charles J. Hitch
President
University of California

Dr. Robert Lamson
Assistant Vice President -
Planning and Budgeting
University of Washington

Dr. Henry Levin
Graduate School of Education and
Department of Economics
Stanford University

Dr. Bertram Levy
Director of the University Budget
New York University

Dr. Thomas Mason
University of Colorado
Boulder, Colorado

Professor C. B. McGuire
Graduate School of Public Policy
UC Berkeley

Dr. Joseph W. McGuire
Vice President - Planning
University of California
Statewide Offices

Dr. Jacob Michaelsen
Department of Economics
UC Santa Cruz

Internal Pricing Mechanisms Workshop
Workshop Participants - continued

Mr. James P. Mnookin
Office of the Provost
Princeton University

Dr. Alexander M. Mood
Director, Public Policy Research
Organization
UC Irvine

Dr. Roy Radner
Department of Economics
UC Berkeley

Mr. Michael M. Roberts
Director of Administrative Computing
Stanford University

Dr. Kenneth D. Roose
Educational Consultant
and Economist
Fort Lauderdale, Florida

Mr. Warren Sanderson
National Bureau of Economic
Research
New York, New York

Dr. Robert Sproull
President
University of Rochester

Dr. George B. Weathersby
Associate Director, Office of
Analytical Studies
University of California
Statewide Offices

WORKSHOP ON INTERNAL PRICING MECHANISMS FOR UNIVERSITY RESOURCE ALLOCATION

Agenda

Wednesday, July 7, 1971

2:00	Opening remarks and introductions - Dr. Fred Balderston
2:15 - 5:00	Session I - Internal Prices from the Perspective of the University Administrator and Decision-Maker

Thursday, July 8, 1971

9:00 - noon	Session II - Economic Theory and Internal Prices -- Some Theoretical and Practical Considerations
12:00 - 4:30	Session III - Resources that Might be Priced -- Techniques, Problems and Examples

Friday, July 9, 1971

9:00 - noon	Session IV - Planning, Implementation, and Information Systems Associated with Use of Internal Prices
1:30 - 3:00	Session V - Different Perspectives on Internal Prices

Panel membership for the Session discussions is listed in Paper P-24, "Internal Pricing Within the University - A Conference Report," edited by David W. Breneman.

WORKSHOP ON INTERINSTITUTIONAL COOPERATION IN HIGHER EDUCATION

November 2-3, 1972

Workshop Participants

Dr. Robert F. Adams
Vice Chancellor-Planning
UC Santa Cruz

Dr. Frederick E. Balderston
Chairman, Center for Research in Management Science
UC Berkeley

Ms. Jane Bolce
Research Assistant, Ford Program for Research in University Administration
UC Berkeley

Dr. North Burn
Coordinator, Five Colleges
Amherst, Massachusetts

Dr. Fritz Grupe
Director, Associated Colleges of the St. Lawrence Valley
Potsdam, New York

President Charles J. Hitch
University of California
Statewide Offices

Dr. Frederick Jackson
Director, Committee on Institutional Cooperation
Evanston, Illinois

Dr. Frances Kelly
Division of College Support
U.S. Office of Education
Washington, D.C.

Ms. Hannah Kreplin
Research Assistant, Ford Program for Research in University Admin.
University of California
Berkeley

Dr. Robert Kroepsch
Executive Director
Western Interstate Commission on Higher Education
Boulder, Colorado

Dr. Richard Lancaster
President
Simpson College
Indianola, Iowa

Dr. Eugene C. Lee
Director, Institute of Governmental Studies
UC Berkeley

Dr. Jacob Michaelsen
Department of Economics
UC Santa Cruz

Dr. Robert O'Neil
Provost
University of Cincinnati

Dr. Lewis D. Patterson
American Association on Higher Education
Washington, D.C.

Vice President John Perkins
University of California
Statewide Offices

Mr. Ward C. Sangren
Coordinator, Office of Comptroller
Activities
University of California
Statewide Offices

Dr. Richard Sax
Executive Director
San Francisco Consortium for
Higher Education and Urban Affairs
San Francisco, California

Dr. David Saxon
Executive Vice Chancellor
UC Los Angeles

Mr. Frank Schmidtlein
Senior Researcher, Ford Program for
Research in University Administration
UC Berkeley

Dr. Neil J. Smelser
Professor of Sociology
UC Berkeley

Mr. John Stanford
Director, Business Services and
Accounting
UC Berkeley

Dr. Herman Stein
University Professor
Case Western Reserve University
Cleveland, Ohio

Dr. Clifford T. Stewart
Director of Institutional Research
The Claremont Colleges
Claremont, California

Rev. John Whalen
Secretary
Consortium of Universities
Washington, D.C.

Dr. Prince Wilson
Executive Secretary
Atlanta University Center
Atlanta, Georgia

The substance of the discussion pursued in this workshop is detailed in Paper P-41, "Interinstitutional Cooperation in Higher Education: An Analysis and Critique," Hannah Kreplin and Jane Bolce.

MEETING ON NATIONAL CENTER FOR HIGHER EDUCATION MANAGEMENT SYSTEMS

January 10, 1973

List of Participants

Joseph W. McGuire
Vice President-Planning
UC Statewide Offices
(co-chairman)

Frederick E. Balderston
Chairman, Center for Research in Management Sciences
UC Berkeley
(co-chairman)

Robert F. Adams
Assistant Chancellor-Planning
UC Santa Cruz

Sandra Archibald
Office of the Vice President-Planning
UC Statewide Offices

Charles J. Courey
Associate Director of the Budget
UC Statewide Offices

Roger Emanuel
Office of Vice President-Planning
UC Statewide Offices

Loren Furtado
Assistant Vice President-Planning, and Budget Director
UC Statewide Offices

Adrian H. Harris
Assistant Chancellor-Planning
UC Los Angeles

Peter Jegers
Office of Vice President-Planning
UC Statewide Offices

Walter L. Johnson
Office of Vice President-Planning
UC Statewide Offices

William W. Lewis
Director, Analytical Studies
UC Statewide Offices

Robert Low
Vice President
Portland State University

Garland P. Peed
Assistant Superintendent of Business
State Center Junior College District
Fresno, California

Michael M. Roberts
Associate Controller
Stanford University

Frank Schmidtlein
Senior Researcher, Ford Program for Research in University Administration
UC Berkeley

Donovan E. Smith
Office of Vice President-Planning
UC Statewide Offices

George J. Turner
Director, Information Systems
UC Statewide Offices

Gary Wagner
Office of Vice President-Planning
UC Statewide Offices

APPENDIX D

PARTICIPANTS FOR WORKSHOP "ISSUES IN COLLEGE AND UNIVERSITY MANAGEMENT"

July 18-24, 1971

Mr. William C. Adkisson
Vice President - Business & Finance
Seattle University
Seattle, Washington 98122

Dr. Alec P. Alexander
Academic Assistant to Chancellor
University of California
Santa Barbara, California 93106

Dr. E. James Archer
Vice President - Academic Affairs
University of Rhode Island
Kingston, Rhode Island 02881

Dr. Raymond F. Bacchetti
Associate Provost and Director
of Academic Planning
Stanford University
Stanford, California 94305

Mr. Leonard C. Barnes
Vice President
Southern University
Shreveport, Louisiana 71107

Dr. David G. Barry
Vice President and Provost
Evergreen State College
Olympia, Washington 98501

Dr. Richard F. Barton
Director-Office of Planning & Analyses
Texas Tech University
Lubbock, Texas 79409

Dr. Thomas F. Bates
Vice President-Planning
Pennsylvania State University
University Park, Pennsylvania 16802

Dr. Kenneth L. Beasley
Research and Development Officer
Illinois Board of Higher Education
Northern Illinois University
DeKalb, Illinois 60115

Mr. Anthony Birch
University Budget Officer
Oregon State University
Corvallis, Oregon 97331

Dr. Joseph Blumel
Vice President-Academic Affairs
Portland State University
Portland, Oregon 97207

Dr. Frank M. Bowen
Consultant, State Department of Finance
State of California
Sacramento, California 95814

Dr. David Breneman
Department of Economics
Amherst College
Amherst, Massachusetts 01002

Mr. Thomas C. Burnette
University Registrar
State University of New York-Albany
Albany, New York 12203

Mr. Patrick M. Callan
Consultant, Joint Committee on the
Master Plan
California Legislature
Sacramento, California 95814

Dr. Mariam K. Chamberlain
Program Officer, Higher Education and
Research
The Ford Foundation
New York, New York 10017

Mr. Hale Champion
Vice President-Finance
Harvard University
Cambridge, Massachusetts 02138

Dr. James V. Clark
Federal Executive Institute
Route 29, North
Charlottesville, Virginia 22903

Mr. Kenneth D. Creighton
Deputy Vice President for Finance
Stanford University
Stanford, California 94305

Mr. James J. Culliton
Assistant to the Vice President
Administration and Personnel
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dr. Robert H. Davis
Assistant Provost and Director,
Educational Development Program
Michigan State University
East Lansing, Michigan 48823

Mrs. Mary F. DeSandre
Associate Systems Coordinator
Colorado Commission on Higher Education
Denver, Colorado 80203

Dr. Fouad El Taher
State University College of Arts & Science
Professor of Economics and Business Admin.
Plattsburgh, New York 12901

Mr. Joe F. Evans
Associate Vice Chancellor-Administrative
Services
Washington University
St. Louis, Missouri 63130

Dr. James C. Goodwin
Director, Office of Equal Employment
Opportunity
University of California
Berkeley, California 94720

Dr. Glen H. Grant
Assistant Vice Chancellor -
Administrative Services
University of California
Berkeley, California 94720

Mr. LeRoy E. Graymer
Associate Dean
Graduate School of Public Affairs
University of California
Berkeley, California 94720

Mr. G. Gilles Guerin
Universite de Montreal
C. P. 6128
Montreal 101, Quebec

Dr. Irma T. Halfter
Vice President, Analytic Studies
De Paul University
Chicago, Illinois 60604

Mr. Bertrand L. Hansen
Director of Research
Committee of Presidents of
Universities of Ontario
Toronto 181, Ontario Canada

Dr. Warren R. Harden
Director-Academic Planning and
Institutional Research
Illinois State University
Normal, Illinois 61761

Mr. Harold H. Harger
Assistant to the Dean
College of Engineering
University of Michigan
Ann Arbor, Michigan 48104

Mr. D. Michael Heiden
Vice President-Administration
McMaster University
Hamilton 16, Ontario Canada

Mr. Carl F. Hartman
Assistant Vice Chancellor-
Academic Affairs
University of California
Irvine, California 92664

Dr. Ann M. Heiss
Consultant
University of California
San Diego, California

Mr. Robert G. Hendrickson
Operations Research Analyst
National Bureau of Standards
Technical Analysis Division
Washington, D.C. 20234

Mr. Matthew J. Hogan
Student Assistant to the Chancellor
University of California
Davis, California 95616

Dr. Thomas B. Hogancamp
Vice President-Administrative Affairs
Murray State University
Murray, Kentucky 42701

Mr. Freeman Holmer
Vice Chancellor-Administration
Oregon State Department of
Higher Education
Eugene, Oregon 97403

Drs. H. J. Hopman
Bureau van de Universiteit
afdeling Bedrijfseconomische zaken
Spui 21, Amsterdam
The Netherlands

Mr. John L. Imhoff
Professor and Head of Industrial
Engineering
University of Arkansas
Fayetteville, Arkansas 72701

Mr. R. J. in 't Veld
Budgeting Department
University of Leiden
Stationsweg 46
Leiden, The Netherlands

Mr. Takaaki Izumi
Special Assistant to the
Vice President-Business Affairs
University of Hawaii
2425 Campus Road
Honolulu, Hawaii 96822

Dr. Ross P. Jackson
University Registrar
Day Hall
Cornell University
Ithaca, New York 14850

Mr. E. Ray Jenkins
Assistant to the Chancellor
Indiana University
Kokomo, Indiana 49601

Dr. Hans H. Jenny
Vice President-Business and Finance
The College of Wooster
Wooster, Ohio 44691

Mr. William Jones
Vice President-Financial Affairs
North Carolina Central University
Durham, North Carolina 27707

Dr. George Kaludis
Vice Chancellor-Operations and
Fiscal Planning
Vanderbilt University
Nashville, Tennessee 37203

Mr. Lloyd Keisler
Controller
Indiana University
Bloomington, Indiana 47401

Dr. Gordon W. Kingston
Assistant to the Executive Director
Minnesota Higher Education
Coordinating Commission
St. Paul, Minnesota 55101

Dr. David W. Kramer
Assistant Dean for Regional
Campus Administration
Indiana University
Bloomington, Indiana 47401

Mr. Kenneth L. Kutina
Director of Operations, Planning
and Analysis
Case Western Reserve School of
Medicine
Cleveland, Ohio 44106

Dr. Robert D. Lamson
Director of Planning Studies
University of Washington
Seattle, Washington 98105

Dr. Edgar Lee, Jr.
Associate Dean-Administration
Case Western Reserve School of
Medicine
Cleveland, Ohio 44106

Mr. Werner Lendenmann
Director of Planning
University of California
San Diego, California 92037

Dr. Al M. Loeb
Program Budget Manager -
Education Systems
California State Department of Finance
Sacramento, California 95814

Dr. John M. Lyons
Assistant Director for Research
Illinois State Board of Higher
Education
Chicago, Illinois 60601

Dr. Daniel E. Marvin, Jr.
Associate Director
State Council of Higher Education
Richmond, Virginia 23219

Mr. Errol W. Mauchlan
Assistant Chancellor-Budget
University of California
Berkeley, California 94720

Mr. Matt Mazer
65 Church Lane
Scarsdale, New York 10583

Dr. William R. McConnell
Executive Secretary
State Coordinating Board
New Mexico Board of Educational Finance
Santa Fe, New Mexico 87501

Dr. Archie L. McPherran
Assistant Chancellor, Fiscal Affairs
California Community Colleges
Sacramento, California 95814

Mr. Carlos Hector Mena
Chemical Engineering
U.N.A.M.
Division del Norte 1255
Mexico, D.F., Mexico

Dr. Vergil V. Miller
Dean, School of Business Administration
Sacramento State College
6000 Jay Street
Sacramento, California 95819

Mr. John H. Noble, Jr.
Institutional Studies Officer
Montana University System
Helena, Montana 59601

Dr. T. K. Olson
Assistant to the President-
Academic Affairs
York University
4700 Keele Street
Downsview, Toronto Ontario

Mr. Felipe Padin
Coordinator, Centro de Cibernetica
Aplicada a la Quimica
U.N.A.M.
Ciudad Universitaria
Mexico D.F. 20, Mexico

Dr. Robert J. Parden
Dean, School of Engineering
Director, Institutional Planning
University of Santa Clara
Santa Clara, California 95053

Dr. Satish Parekh
Vice President-Administration
and Finance
Federal City College
Washington, D.C. 20001

Dr. Wayne C. Patterson
Executive Vice President
The University of Vermont
Burlington, Vermont 05401

Mr. Donald E. Pearson
Assistant Director-Office of
Planning and Institutional Studies
University of Rochester
Fairport, New York 14450

Dr. Howard E. Petch
Academic Vice President
University of Waterloo
Waterloo, Ontario, Canada

Mr. Kent R. Peterson
Manager of Analytical Studies
Stanford University
Stanford, California 94305

Dr. Jack M. Potter
Associate Dean
Graduate Division
University of California
Berkeley, California 94720

Mr. Ignacio Riva Palacio
Adviser, Technical Planning Commission
Universidad Nacional Autonoma
de Mexico
Cuidad Universitaria
Mexico 20, D.F., Mexico

Dr. James F. Rogers
Educational Program Officer
Division of College Programs
U.S. Office of Education
Washington, D.C. 20202

Mr. Leonard C. Romney
Staff Analyst and Project Manager
Western Interstate Commission for
Higher Education
Boulder, Colorado 80302

Dr. William D. Rubenstein
Coordinator, Intercampus Council
of Graduate Organizations
Graduate Division
University of California
Davis, California 95616

Mr. Frank A. Schmidtlein
Senior Research Officer
U.S. Office of Education
Washington, D.C. 20202

Dr. Robert A. Schwabe
Director-Institutional Research
California State College
San Bernardino, California 92407

Dr. Bernard F. Sliger
Executive Director
Coordinating Council Higher Education
Baton Rouge, Louisiana 70804

Dr. Sherman E. Smith
Vice President-Administration
and Development
University of New Mexico
Albuquerque, New Mexico 87106

Mr. Floyd K. Stearns
Executive Director
Oregon Educational Coordinating
Council
Salem, Oregon 97310

Dr. Robert C. Stephenson
Vice President for Research and
Sponsored Programs
The Ohio State University
Columbus, Ohio 43212

Dr. A. A. Sterns
Director of PPBS
University of Georgia
Athens, Georgia

Mr. Kenji Sumida
Coordinator-Planning & Budgeting
University of Hawaii
Honolulu, Hawaii 96822

Mr. Richard S. Takasaki
Executive Vice President
University of Hawaii
Honolulu, Hawaii 96822

Mr. Ian B. Tate
Accountant
Monash University
Clayton, Victoria 3168
Australia

Mr. A. Dale Tomlinson
Assistant Chancellor, Budget and
Analysis
University of California
Santa Barbara, California 93106

Dr. Chester C. Travelstead
Vice President-Academic Affairs
University of New Mexico
Albuquerque, New Mexico 87106

Mr. Raymond Varley
Vice Chancellor, Business and Isla
Vista Affairs
University of California
Santa Barbara, California 93106

Dr. Marvin B. Wampler
Acting Executive Dean
Fresno State College
Fresno, California 93710

Dr. Frank A. Work
Executive Assistant to the
Vice Chancellor-Academic Programs
University of California
Los Angeles, California 90024

WORKSHOP ON ISSUES IN COLLEGE AND UNIVERSITY MANAGEMENT

INVITED SPEAKERS AND DISCUSSION LEADERS

Keynote Speakers:

Earl F. Cheit, Professor of Business Administration, University of California, Berkeley
Gerald Faverman, Legislative Fiscal Analyst, State of Michigan
Sanford H. Kadish, Professor of Law, University of California, Berkeley

Discussion group leaders and topics:

Robert F. Adams, Academic Assistant to the Chancellor, University of California, Santa Cruz, and Jacob Michaelsen, Assistant Professor of Economics, University of California, Santa Cruz; "Collegial and Other Alternative Structures"

David P. Gardner, Vice President-Public Service Programs, University of California; "The "Open University" and Other Models of Extended Education"

Lindley R. Sale, Assistant to the Chancellor, University of California, Berkeley; "Establishment of Program Priorities for the Use of Physical Facilities"

Jacob Michaelsen, Assistant Professor of Economics, University of California, Santa Cruz; "Futurist Views of Education"

David Breneman, Assistant Professor of Economics, Amherst College; "Conduct and Productivity of Doctoral Programs," "Enrollment, Resource Acquisition and Incentives for Program Priorities," (with George Weathersby), and "Internal Pricing for University Resource Allocation"

Kenneth Creighton, Deputy Vice President for Finance and Controller, Stanford University, "Methods of Indirect Cost Recovery"

Loren Furtado, Director of the Budget, University of California, "Budgetary Control"

Lyle Gainsley, Director of Admissions and University Registrar, University of California, "Articulation between Secondary and Higher Education Programs and Among Departments of the University"

Sanford Kadish, Professor of Law, Boalt Hall, University of California, Berkeley, "Collective Bargaining and Faculty Organization"

Robert Lamson, Director of Planning Studies, University of Washington, "Costs of Graduate Education"

Roy Radner, Professor of Economics and Statistics, University of California, Berkeley, "Analysis and Implications of Changing Student/Faculty Ratios"

Donovan Smith, Specialist in Physical Planning, Office of the Vice President-Planning and Analysis, University of California, "Issues in the Utilization of Physical Facilities"

John Stanford, Assistant Vice President-Business and Finance, University of California, "Recharge Systems"

George B. Weathersby, Assistant Director-Office of Analytical Studies, University of California, "Enrollment, Resource Acquisition and Incentives for Program Priorities," (with David Breneman), "Output Oriented Costing," and "Resource Planning Models"

Burton Wolfman, Associate Director, Office of Analytical Studies, Vice President-Planning and Analysis, University of California, "Measurement of Faculty Activity and Outputs"

Ad hoc discussion groups were also convened by the participants on the following topics:

Salary Comparison Issues
Targets of Ph.D., Graduate and Undergraduate Programs
WICHE: Resource Requirements Prediction Model: Planning and Management Systems (RRPM-PMS)
Professionalism in Administration - Who Should be the Administrators and Why?
Changing Role of Private Higher Education: Should Private Institutions be Publicly Supported and What Impact Could be Expected?
Ways of Increasing Productivity of Higher Education